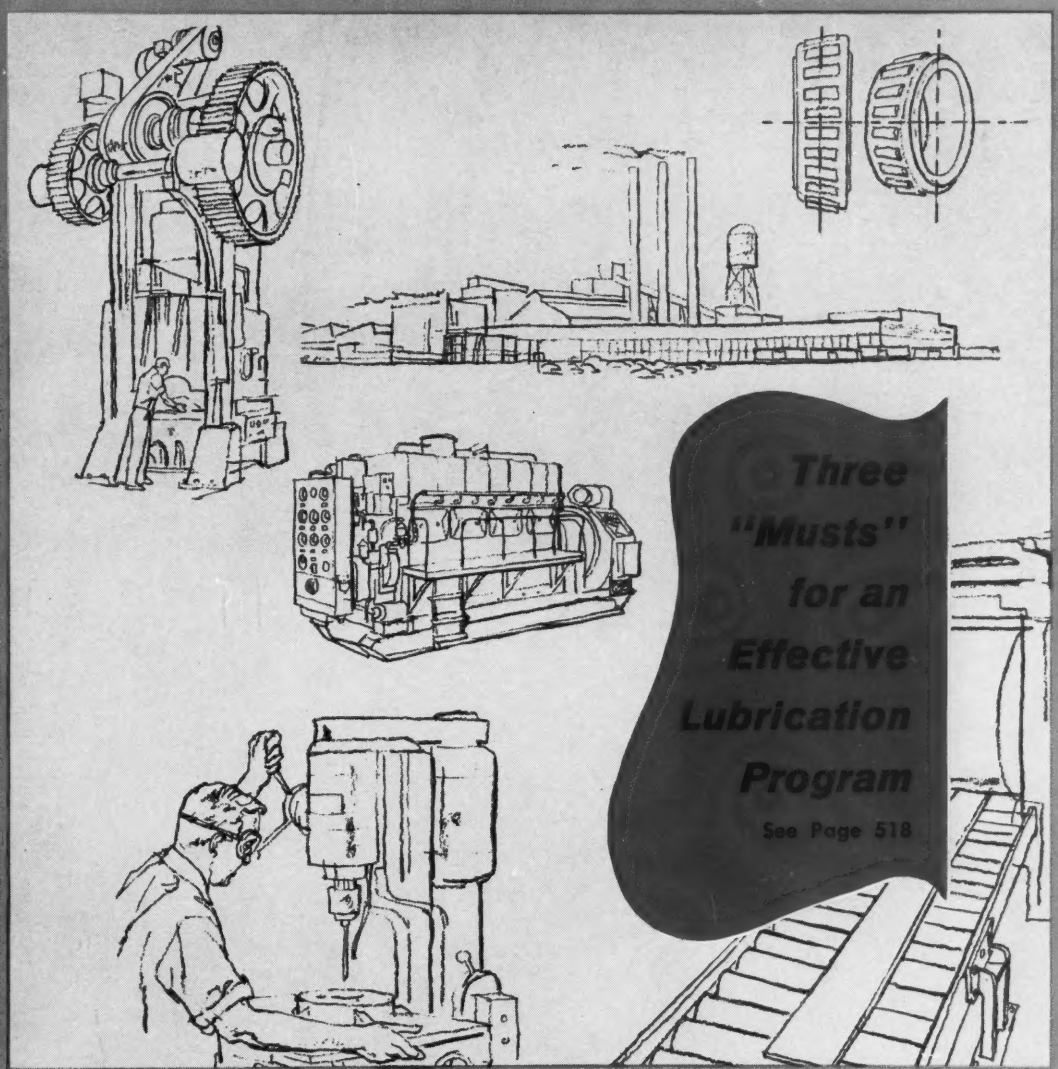
Vol. 17, No. 11 November, 1961

LUBRICATION ENGINEERING

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE



JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

CLIMAX MOLYBDENUM

Molysulfide® News Digest

CLIMAX MOLYBDENUM COMPANY, a division of American Metal Climax, Inc., 1270 Avenue of the Americas, New York 20, N.Y.

EDITORIAL PAGES OF LEADING TRADE MAGAZINES FEATURE MoS_2 INFORMATION

Higher temperatures, lower temperatures, greater pressures, longer lubrication life, all have combined to focus more attention on the uncommon lubricating values of molybdenum disulphide.

That's why editors are devoting more and more space to descriptions of what MoS_2 can and cannot do.

One article tells how MoS_2 prevents harmful friction in brake linings. Another discusses its use as a compressor lube substitute. Still another reports on tests of epoxy-resin compositions containing high concentrations of MoS_2 for industrial use on bearings, seals and friction strips.

Press fittings, wire drawing, cutting tools, ball joints—there are MoS_2 stories about these uses, too.

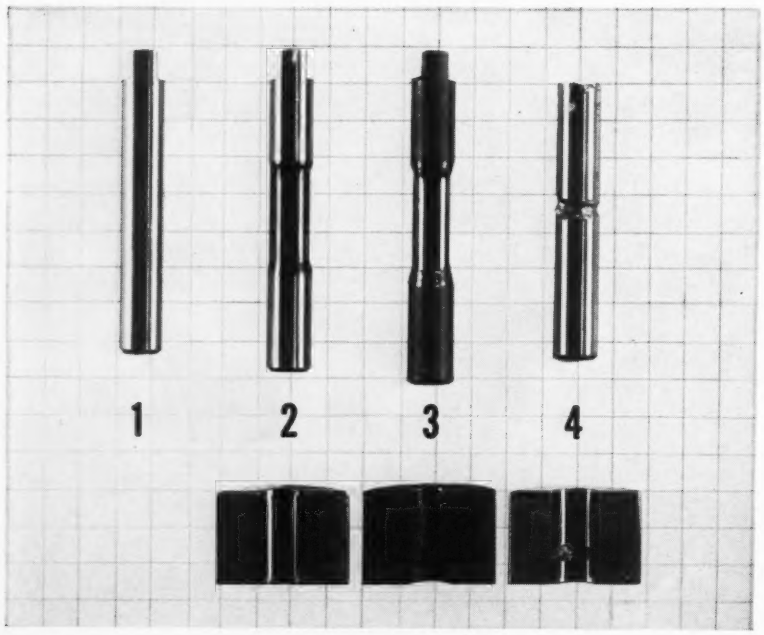
MoS_2 as a solid-film dry lubricant has been the subject of several articles. One details high-temperature properties; another describes a new bearing design that can increase bearing life as much as 450%.

Write us for a complete bibliography of published material on molybdenum disulphide.

P.S. Climax publishes a newsletter that describes even more uses. Let us know if you'd like your name on the mailing list.

When writing, refer to CL-116

Proof of MoS_2's High-Pressure Properties



Photograph above shows mild steel test pins. No. 1: Unused pin, No. 2 (lubricated with mineral oil and Molysulfide) and No. 3 (with Molysulfide bonded coating) were subjected to rotating pressures between bearing halves. Both were elongated and extruded without galling, seizing, or weight loss. No. 4 shows typical failure with conventional lubricant. Note that the key sheared off and pin and block were galled and seized.

When writing, refer to CL-118

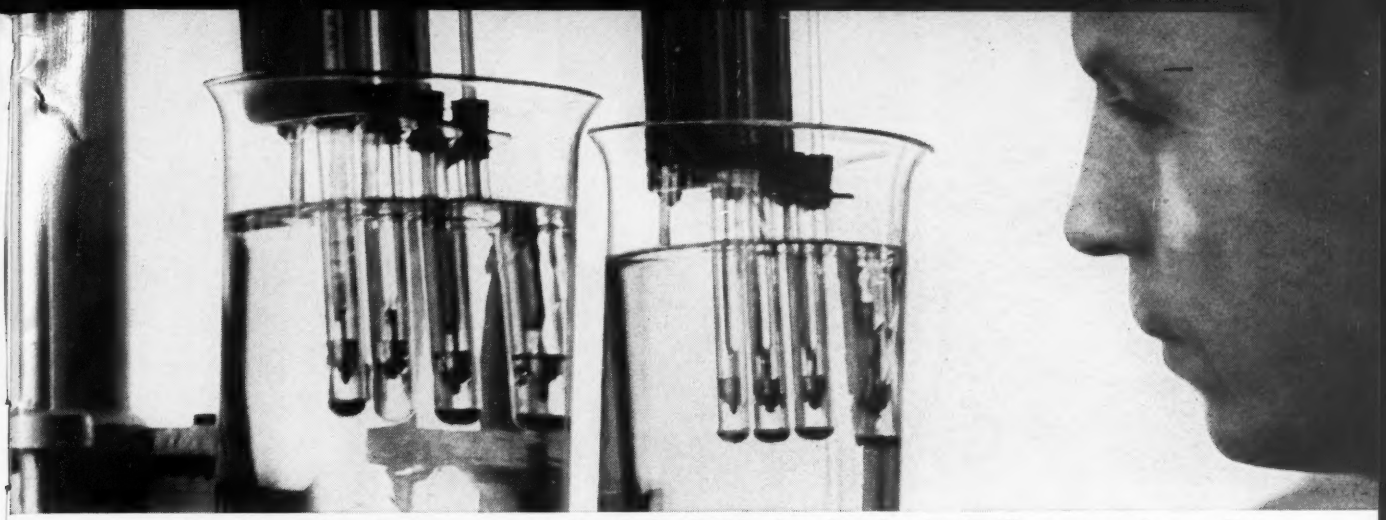
Use of MoS_2 Paste-Type Concentrates Shows Growth

These lubricants, containing higher-than-usual amounts of Molysulfide, first proved their value in press fit assemblies of pump gears and shafts. By completely preventing galling and seizing, and eliminating bent shafts, MoS_2 saved one company $1,821 annually on that operation alone.

The use of MoS_2 then spread to pins, engine block studs, and threaded connections, where not only ease of assembly but ease of disassembly is important.

Today, Molysulfide paste-type concentrates have proved to be the most versatile of MoS_2 lubricants. They are particularly effective wherever high load conditions exist—on splines, universal joints, ball joints, sleeve bearings, and machine ways and as wear-in and drawing lubricants.

When writing, refer to CL-117



Dropping point test shows how greases react to heat. Beaker fluid has been heated to 390°F. All greases tested except Darina (second tube from left) have passed from solid to liquid state.

BULLETIN:

Shell reveals the remarkable new component in Darina Grease that helps it save up to 35% on grease and labor costs

Darina® Grease is made with Microgel*, the new thickening agent developed by Shell Research.

Darina lubricates effectively at temperatures 100° hotter than most conventional soap base greases can withstand.

Read how this new multi-purpose industrial grease can help solve your lubricating problems and even save you up to 35% on grease and labor costs.

THERE IS no soap in Darina Grease. No soap to melt away—wash away—or dissolve away.

Instead of soap, Darina uses Microgel—a grease component developed by Shell Research.

What Microgel does

Because of Microgel, Darina has no melting point. It won't run out of gears or bearings.

Compared with most conventional soap-base greases, Darina provides significantly greater protection under adverse service conditions.

Mix water into Darina and the grease does not soften. It shrugs off water—won't emulsify.

Resists heat

Darina will withstand operating temperatures 100° hotter than most conventional multi-purpose greases. It cuts leakage and reduces the need for special high-temperature greases.

Also, Darina resists slumping, thus forming a more effective seal against foreign matter.

Saves money

Shell Darina can reduce maintenance expenses while it protects your machinery. Savings of up to 35% on grease and labor are quite possible.

In some cases lubrication intervals have been extended to double what they were before. Less grease is consumed and less time consumed applying it.

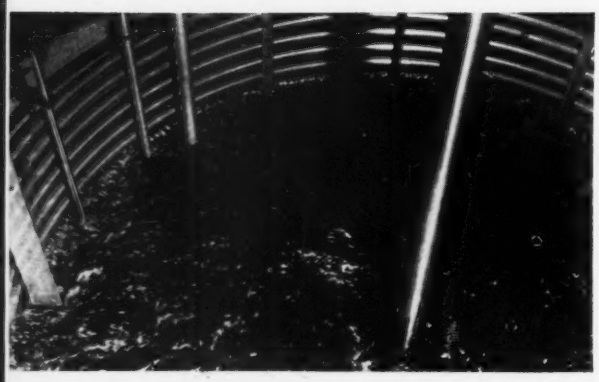
For details, see your Shell Representative. Or write: Shell Oil Company, 50 West 50th Street, New York 20, New York.

*Registered Trademark

SHELL

A BULLETIN FROM SHELL
—where 1,997 scientists are helping to provide better products for industry

Precise control for precisely right roll oils



CONTROLLED REACTION takes place in this 5200-gallon vessel, of stainless steel.

Advanced new instrumentation, giving complete control of environment and the cycle of reaction, is enabling us to synthesize and process all-domestic roll oils to exacting new requirements. For example, Palmoshield #104 lubricant, developed for "ultra thin" tin plate, has proved eminently successful in mills rolling in the .002—.006 range.

Ironsides engineers welcome your inquiry where tailored-to-mill Palmoshield may solve a problem — tin plate, long terne and coating lines, too. Write or phone THE IRONSIDES COMPANY, Columbus 16, Ohio (CA 4-2228).

Ironsides

SHIELD PRODUCTS

Compounders of Palmoshield and other Shield lubricants

Volume 17, No. 11
November, 1961

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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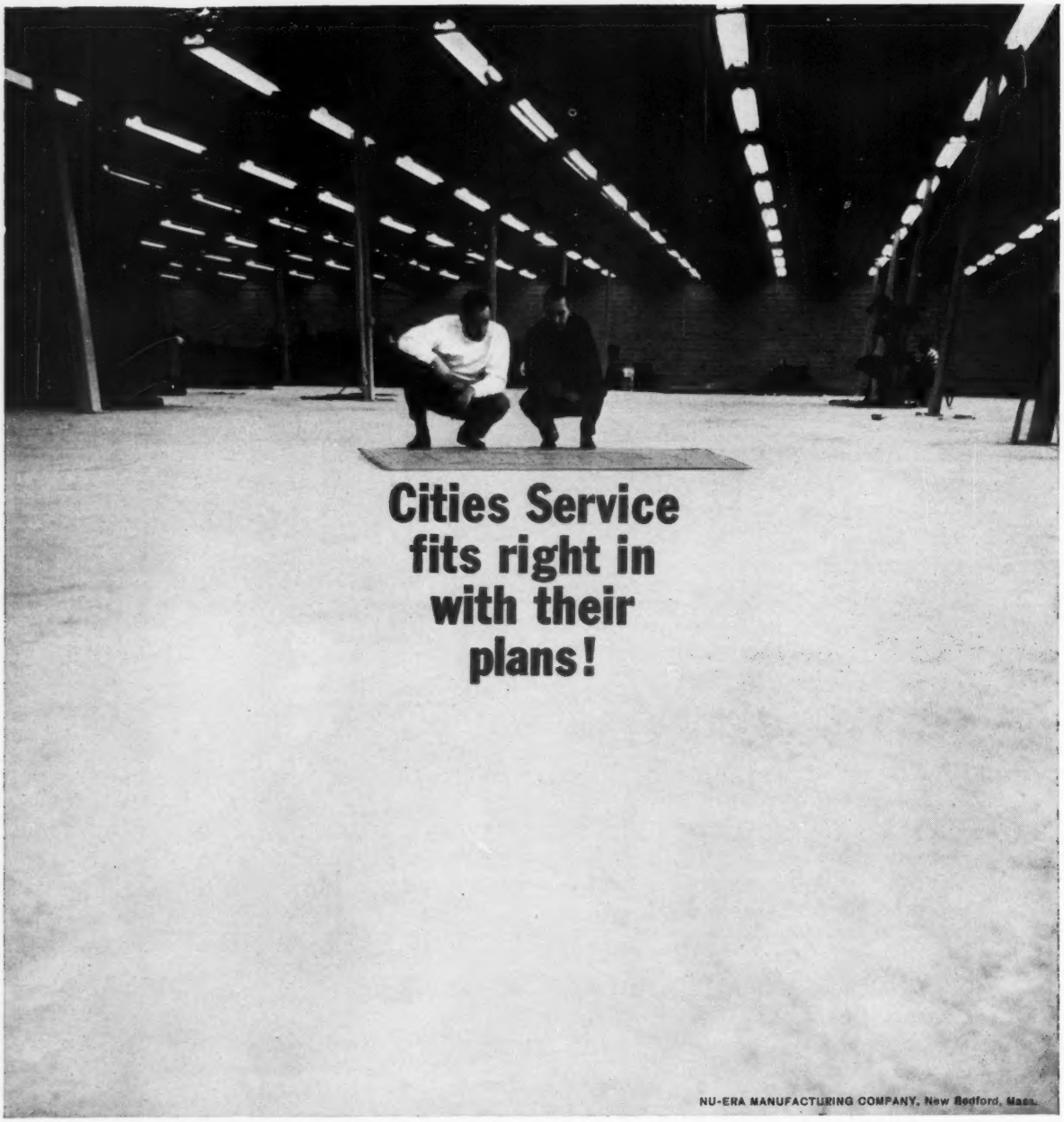


There's a bright future ahead for Nu-Era, manufacturer of replacement gears. The firm recently built this huge plant to handle increased orders... and Cities Service definitely fits in with their plans. Says General Manager Bill Rebone, "At first, all cutting oil brands seemed to be the same. However, we soon realized that Cities Service oils were giving us superior performance in every respect. Most of our gears are made of #5135 steel, a real tough customer to work with. Yet, we find we're getting long tool life, extra clean cuts with Cities Service Chillo 30 Cutting Oil." Nu-Era now relies, exclusively, on Cities Service for their metal machining fluids. Find out how Cities Service can fit in with your plans. Simply contact your nearest Cities Service office or write: Cities Service Oil Company, 60 Wall Street, N.Y. 5, N.Y.

CITIES SERVICE

Out Front in Quality... Out Front in Service, too!

LUBRICATION IN THE NEWS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

ARMY ESTABLISHES QUALIFIED PRODUCTS LIST OF GREASE, AUTOMOTIVE AND ARTILLERY

The Rock Island Arsenal, Department of the Army, has announced the intention to establish a Qualified Products List for Grease, Automotive and Artillery, under Specification MIL-G-10924B. Companies which have a product meeting the requirements of this specification are urged to contact the Commanding Officer, Rock Island Arsenal, Rock Island, Illinois, Attn.: Laboratory, for an opportunity to have their products tested, since in making future awards, awards will be made only for such products as have been tested and approved for inclusion in the Qualified Products List. (Source: The Ordnance Corp, Department of the Army, Rock Island Arsenal, Rock Island, Ill.)

GREASE INSTITUTE SPONSORS NEW RESEARCH

The National Lubricating Grease Institute has announced the sponsorship of a new research fellowship on non-Newtonian flow in bearings, which began with the academic year, September, 1961.

The proposed research will be conducted by the chemical engineering department of Northwestern University, Evanston, Illinois, under the guidance of John C. Slattery, assistant professor. The program has as its broad objective the analysis of flow of non-Newtonian fluids in bearings. It is anticipated that for the first year the study will be limited to an infinitely long journal bearing filled with a grease described by the Sisko model. The desired results would be the effect of grease properties and eccentricity upon velocity distribution, pressure distribution, load carrying capacity and friction. It is hoped that this research will result in improved procedures in bearing design, and a better understanding of the behavior to be desired in greases. (Source: National Lubricating Grease Institute)

NATIONAL CARBON INVESTS HALF-MILLION IN HIGH-DENSITY GRAPHITE FACILITIES

A $500,000-expansion of its facilities for the production of high-density graphite for the nation's space program has been announced by National Carbon Company, Division of Union Carbide Corporation, New York, N. Y. Construction work on the additional facilities at its Lawrenceburg, Tennessee plant has already begun, with completion scheduled for late this year.

Development of a "family" of high-density graphites with approximately two to three times the high-temperature strength of conventional graphites was announced by National Carbon last October. Details of the production process have been classified by the government, and most of the material manufactured to date has been earmarked for military applications. (Source: National Carbide Company)

NEW PROCESS IN LUBRICANT MANUFACTURING DEVELOPED

A new process for the manufacture of critical specification lubricants—The 'Electro-Thermatic'$^{t.m.}$ process—has been developed by Southwest Grease and Oil Company, Wichita, Kansas.

The research developer states that production results now on hand have indicated that the capabilities of the 'Electro-Thermatic'$^{t.m.}$ process far exceed those obtainable with hot oil contact, gas fired, or steam methods used in the past. The lubricants produced are said to be more closely controlled, and processing temperature can be held to plus or minus one-half degree Fahrenheit. This new installation will substantially add to Southwest Grease and Oil Company's manufacturing facilities, capable of producing one-half million pounds of lubricants daily. (Source: Southwest Grease and Oil Company, Inc.)

VOLATILE INHIBITORS PROVE THEIR WORTH IN 10 YEAR TESTS

Volatile corrosion inhibitors can be successfully used to prevent rust in stored gun and howitzer tubes, resulting in time and labor savings over present petrolatum type corrosion preventives. This finding is reported in an Army evaluation study of both types of rust protection released to science and industry through the Office of Technical Services, Business and Defense Services Administration, U.S. Department of Commerce, Washington 25, D.C.

Also available from OTS is an Army research report on literature relating to humidity and temperature effects on atmospheric corrosion rates. A number of suggestions are presented for improving the effectiveness of controlled warehouse storage in protecting steel against corrosion. Both reports are described below.

The Use of Volatile Corrosion Inhibitors as a Preservative Medium for Long Term Storage of Ordnance Materiel — Addendum VII — Results After Ten Years of Exposure. R. E. Johnson, Rock Island Arsenal Laboratory, Department of the Army. February 1961. 49 pages. (Order PB 171 516 from OTS, U.S. Department of Commerce, Washington 25, D. C., price $1.25.)

Volatile corrosion inhibitors proved as effective as petrolatum type corrosion preventives in protecting gun and howitzer tubes and other sintered and nonferrous specimens of ordnance materiel from rust during a 10-year storage period, according to this research. Use of these inhibitors to impregnate paper for packaging gun and howitzer tubes for storage should provide savings in time and labor because, unlike the petrolatum type preventive, they require no degreasing after removal of the materiel from storage, the report states.

(*Continued on page 505*)

Compact cartridge pumps provide pressure lubrication at minimum cost

by E. H. Schanzlin
Chief Engineer, Tuthill Pump Company

An opportunity for savings exists in many original equipment applications involving pressure lubrication . . . where, in many instances, foresight on the part of the designer will permit the use of a "cartridge" pump which can be built directly into the equipment . . . to provide the greatest possible capacity per cubic inch of pump . . . and ordinarily at a price below those for comparable pumps . . . since every possible extraneous element has been eliminated from their design.

14 Different Units

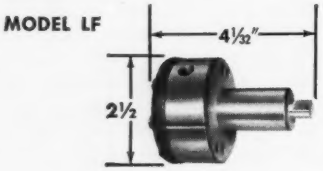
To meet the requirements of these applications Tuthill engineers have developed four different models of cartridge pumps . . . each offered in 3 or 4 sizes for a total of 14 different units . . . for pressures to 200 psi . . . with a capacity range from 56 to 720 gph depending upon pump size and motor speed. These units are all available from stock in any quantity desired. They have been used successfully in many outstanding original equipment applications.

Model LF

Model LF pumps, as shown, have an extremely simple housing and are normally furnished without seals. They are supplied in three sizes with nominal capacities as shown below.

Size	GPH	RPM
00	56	1800
0	105	1800
1	180	1800

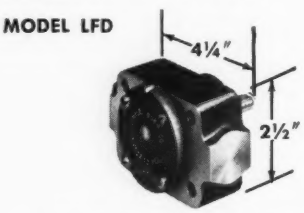
(These nominal capacities will also apply to similar sizes of pumps discussed later.)



Model LF pumps are designed for flange mounting. They offer a choice of internal or external porting. Overall dimensions of these compact units are only 2½" x 4 1/32", and even shorter lengths are possible when pumping conditions permit.

Model LFD

Model LFD cartridge pumps are offered in the same capacity ranges and sizes as model LF. They resemble these basic pumps except that they are provided with a more detailed housing. Model LFD's are designed for flange mounting and normally supplied with either internal porting or ⅜-18 N.P.T. external porting. Shaft seals or ball bearings may also be furnished with these units as an alternate. In the 00, 0, and 1 pump sizes, these units measure 4¼" x 2½" x 3½"

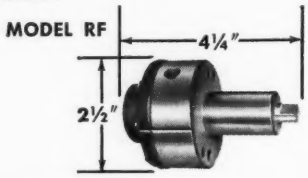


Model LFD pumps are also furnished in pump size 2, with a capacity of 360 gph at 1800 rpm, and 720 gph at 3600 rpm. Overall dimensions are 5⅝" x 3⅞" x 4 15/32".

RF Models

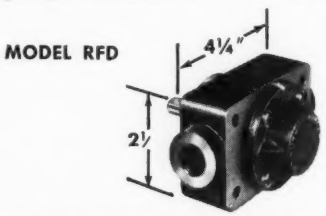
The selection of RF models closely resembles those in the LF range . . . sizes, capacities and general characteristics are identical. However, these units are equipped with Tuthill's special automatic reversing feature which permits driving the pump in either direction without changing the direction of flow . . . with port positions remaining constant . . . without special valving.

The automatic reversing design was developed by Tuthill for applications where the pump must be driven by reversing shafts, or where machinery must be shipped without knowing the ultimate direction of the driving unit. These versatile units have proven their superiority in hundreds of demanding applications.



Model RFD

These units parallel model LFD in capacities, sizes, and general characteristics. Like the model RF above, however, the pumping units have Tuthill's special automatic reversing feature for use with reversing shafts. Dimensions of 00, 0, and 1 sizes are 4¼" x 2½" x 3 29/32". Size 2 pumps measure 5⅝" x 3⅞" x 4 15/32".



Wide Variety of Alternates

In addition to the basic pump models, various alternates can be provided. For example two alternate shaft modifications are offered for maximum adaptability.

Imaginative use of these cartridge pumps may permit significant savings in your designs. In addition to the economical price, their compactness and light weight can eliminate design headaches. These units offer the maximum amount of lubricating capacity for the minimum amount of pump . . . and often at the minimum expenditure of dollars.

For further details write for catalog section 108. Or, send details on your application so Tuthill can offer suggestions on how these units can be incorporated into your design.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.

PUMPS FOR YOUR PURPOSE
TUTHILL PUMP COMPANY
971 East 95th Street, Chicago 19, Illinois

LUBRICATION IN THE NEWS

(*Continued from page* 503)

Two volatile corrosion inhibitors and three petrolatum preventives were evaluated in the study. The first inhibitor consisted of one gram of dicyclohexylammonium nitrite per square foot of paper used to package the materiel; the second contained a minimum of 0.5 grams sodium nitrite and 0.5 grams urea for a total minimum loading of one gram per square foot of paper. Results of the storage tests showed that the inhibitors and the petrolatum preventives were equally effective in protecting the materiel. No significant differences were found in the overall protective effectiveness of the two kinds of volatile inhibitors used.

Humidity and Temperature Effects on Atmospheric Corrosion Rates—Literature Report. R. Le Mar, Rock Island Arsenal Laboratory, Department of the Army. February 1961. 17 pages. (Order PB 171 547 from OTS, U.S. Department of Commerce, Washington 25, D.C., price 50 cents.)

The effectiveness of controlled warehouse storage in protecting steel against corrosion can be increased by the addition of absorption beds and filters to the warehouse's humidity control units, according to this analysis of information from available literature on the effects of relative humidity and dew on the atmospheric corrosion of steel. Use of absorption beds of iron oxide in warehouses is recommended to remove contaminant gases which might prove corrosive to the stored items. Filtering techniques using electrostatic precipitation, and centrifugal, or washing methods, are considered feasible for eliminating airborne particles which act as corrosive agents on metal surfaces. (Source: U. S. Department of Commerce)

BONDED NICKEL ALLOY COATED MOLYBDENUM DEVELOPED

New York Testing Laboratories, Inc. has successfully coated Molybdenum with an alloy bonded Nickel alloy coating. This coating is said to protect Molybdenum at elevated temperatures where it would ordinarily be subjected to severe oxidation corrosion.

Since Molybdenum has a relatively high strength at elevated temperature, this "NIPHOS" process is claimed to increase its life preventing accelerated oxidation.

The applications for this material combination are apparent for high performance aircraft and missiles where temperature effects are important on structural parts. Since Molybdenum has a high strength to weight ratio at elevated temperatures but poor oxidation resistance, the NIPHOS protective coating is a very important step in solving this problem.

The alloy bonding qualities of the coating process allow this material to be worked after coating without exfoliating. (Source: New York Testing Laboratories, Inc.)

ACADEMIC LEAVE PROGRAM SPONSORED

An academic leave program for professionals gives outstanding professional personnel at Westinghouse Electric's research laboratories full salary for one-year of advanced study at the institution of their choice. The program permits individually planned research and study at any university or non-profit institution in the world. (Source: National Society of Professional Engineers)

SKF RESEARCHERS USE RADIOACTIVITY IN BEARING STUDY

Radioactivity shows metal particle transfer from a bearing roller to race —also how much—and under what conditions, say SKF Industries' researchers.

Preliminary radioisotope studies have shown the existence of metal transfer between irradiated roller and non-irradiated race by direct surface contact or through radioactive wear particles carried in the lubricant of a bearing, said the director of engineering and research for the ball and roller bearing maker.

Among the study's bearing user benefits—believed first completed of its type in the industry—is the insurance of proper pressure distribution to add bearing life, ability now to pinpoint the best lubricant for specific conditions, and the technique's usefulness to study surface finishes.

The amount of metal transferring depends on surface finish and pressure, sliding velocity, how long a bearing runs, its temperature, and the type and condition of the lubricant.

SKF intends broadening use of tracer techniques in its new radioisotope facility to examine location of high pressure areas between rolling elements in bearings under different loads, speeds, and lubrication; the effects of lubricants to separate rolling contact bearing surfaces; and the effects of surface finishes and finishing operations on bearing interfacial contact. (Source: SKF Industries)

INDUSTRY NOTES

The establishment of an Indianapolis, Indiana, office to service the entire state of Indiana was announced today by Anti-Corrosive Metal Products Co., Inc., Castleton-On-Hudson, New York.

The company also announced the appointment of Robert Lay as manager of the Indiana operation.

General Bearing Company, Inc. of West Nyack, N. Y., has announced the opening of a new warehouse and office in Miami, Florida, to serve their customers in the Southern area with unground bearings.

Miniature Precision Bearings, Inc., Keene, N. H. has announced the formation of a new division to produce and market a line of low cost miniature ball bearings. The new unit will be called MINA Bearings, a division of MPB, Inc.

In making the announcement, MPB's executive vice president, William M. Scranton, said, "The MINA Bearing Division has been established to broaden the market base for the products of MPB and its division, particularly in non-military markets where cost is the primary factor and ultra-high precision and performance is less critical."

HIGH-SPEED TRACK TESTS

prove high temperature quality of Oronite 1200 Series additives

TRACK TEST

Vehicles used: V-8 passenger cars and both gasoline and diesel powered trucks.

(trucks were loaded at normal gross weight to simulate actual driving conditions)

Test driving: 16 hours per day.

Driving speed: Autos—75 m. p. h. *(continuous operation)*
Trucks—60 & 50 m. p. h. *(continuous operation)*

Test miles: 30,000 for each vehicle

Recent road testing demonstrates the high temperature quality of Oronite 1200 Series lube oil additives. 1200 Series additives were previously noted for superior low-temperature performance—NOW their high-temperature quality also has been demonstrated in both gasoline and diesel powered vehicles.

This testing was carried out by an independent facility with high-speed driving conditions simulated for each type vehicle. Test results showed that oils compounded with 1200 Series additives will match any compounded oil on the market for high-temperature engine performance.

Now lab and field testing has demonstrated both high and low-temperature advantages from oils compounded with Oronite 1200 Series additives.

Why not get the complete story? Data is available to those interested in marketing or compounding better motor oils. For full information—contact the Oronite office nearest you.

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ORONITE DIVISION

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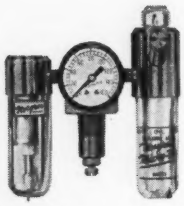
7366

Norgren Lubro-Control Units

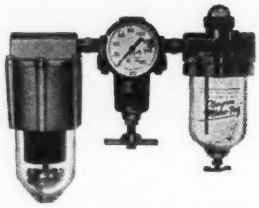
*A complete line of **visible oil feed** lubricator units for air-tools, air cylinders and other air-powered equipment*

NORGREN Micro-Fog Combination Units

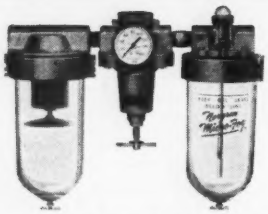
Easily adjustable for the exact amount of lubrication required



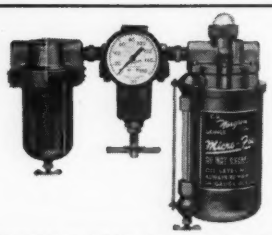
Transparent bowl filter; pressure regulator with gauge; transparent bowl Micro-Fog Lubricator. ⅛" pipe size. ½ oz. lubricator capacity. Small, compact unit for use where space is tight.



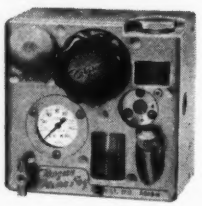
Transparent bowl automatic-drain filter; regulator with gauge; transparent bowl, Micro-Fog Lubricator. ¼", ⅜", ½", ¾", 1" pipe sizes. ½ pt. lubricator capacity.



Transparent bowl manual-drain filter; pressure regulator with gauge; transparent bowl, Micro-Fog Lubricator. ¼", ⅜", ½", ¾", 1", pipe sizes. 2½ pts. lubricator capacity.



Replaceable metal bowl manual-drain filter; pressure regulator with gauge; replaceable metal bowl, Micro-Fog Lubricator with constant oil level. ¼", ⅜", ½", ¾", 1" pipe sizes. 1 qt. lubricator capacity.



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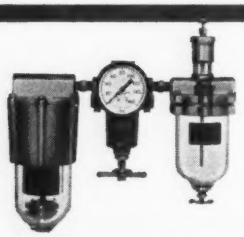
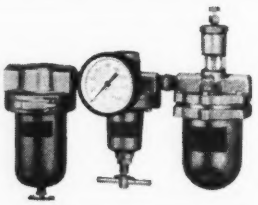
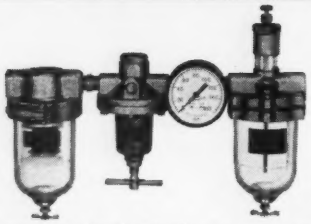


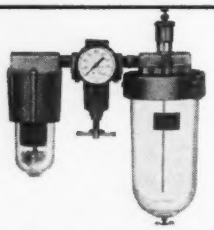
Transparent bowl automatic-drain filter; regulator with gauge; transparent bowl lubricator. ¼", ⅜", ½", ¾", 1" pipe sizes. ½ pt. lubricator capacity.



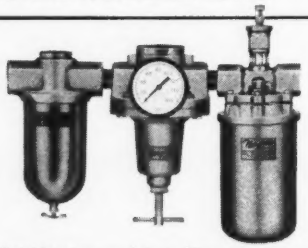
Replaceable metal bowl manual-drain filter; pressure regulator with gauge; replaceable metal bowl lubricator. ¼", ⅜", ½", ¾", 1" pipe sizes. ½ pt. lubricator capacity.



Transparent bowl manual-drain filter; pressure regulator with gauge on tee; transparent bowl lubricator. ¼", ⅜", ½", ¾", 1" pipe sizes. ½ pt. lubricator capacity.



Transparent bowl automatic-drain filter; pressure regulator with gauge; transparent bowl lubricator. ¼", ⅜", ½", ¾", 1" pipe sizes. 1½ qt. lubricator capacity.



Metal bowl manual-drain filter; pressure regulator with gauge; replaceable, metal bowl lubricator. ¾", 1" pipe sizes. 1 qt. lubricator capacity.

Shown here are a few models from Norgren's complete line of air filters, pressure regulators and lubricator units. For full information, call your nearby Norgren representative listed in your phone directory, or write for descriptive literature.

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Who Picks Up The Bill For Society Membership?

The policies of industrial companies on the payment of professional employees' membership costs in technical and professional societies were recently uncovered in a survey made by *Management Record.*

Twenty industrial firms were surveyed and of these, seventeen have procedural rules on the payment of membership expenses.

One of the seventeen pays no part of such costs, considering them to be the engineer's "personal responsibility."

Seven companies pay all membership costs in recognized professional and technical societies.

Three companies expect their employees to pay the membership costs in the first society they join, but are willing to pay thereafter for additional memberships in other societies.

The policy in two companies is to pay only in cases where management has specifically directed employees to join.

Two foot the bill only when memberships can be listed in the company's name.

And finally, the last two surveyed pay all the costs when the employees have been asked by management to join, and divide the costs when the employees join on their own. (Source: *Management Record)*

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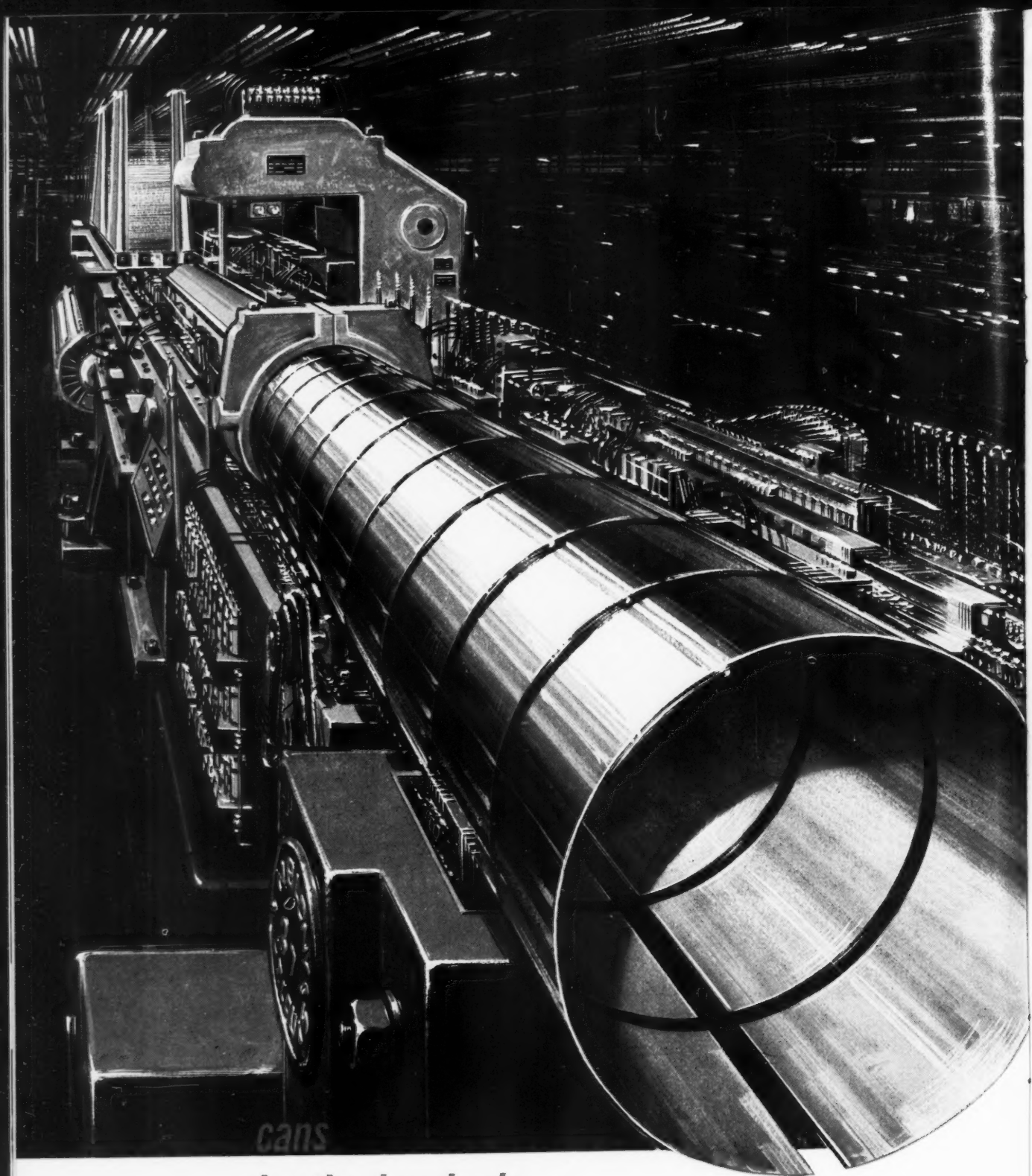

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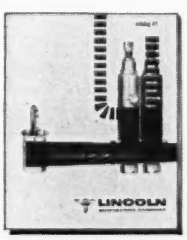

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"Friction and Surface Deformation During Sliding on a Single Crystal of Copper," by J. M. Bailey, Beloit College, Beloit, Mich., and A. T. Gwathmey, University of Virginia, Charlottesville, Va. *(ASLE Paper No. 61LC-4)*

"Chemical Changes in Steel Surfaces During Extreme Pressure Lubrication," by D. Godfrey, California Research Corp., Richmond, Calif. *(ASLE Paper No. 61LC-5)*

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"Extreme Pressure Lubrication and Wear—The Chemical Reactivity and the Extreme Pressure Action of Two Aliphatic Disulfides," by A. Dorinson and V. E. Broman, Sinclair Research Laboratories, Harvey, Ill. *(ASLE Paper No. 61LC-6)*

"Polymer Formation on Sliding Metals in Air Saturated with Organic Vapors," by W. E. Campbell, Consultant, Cleveland 6, Ohio, and R. E. Lee, Jr., General Electric Co., Schenectady, N.Y. *(ASLE Paper No. 61LC-7)*

"Effect of Lubricant Viscosity on Metallic Contact and Friction in a Sliding System," by M. J. Furey and J. K. Appeldoorn, Esso Research and Engineering Co., Linden, N.J. *(ASLE Paper No. 61LC-8)*

"Heat of Preferential Adsorption of Surfactants on Porous Solids and its Relation to Wear of Sliding Steel Surfaces," by A. J. Groszek, British Petroleum Co., Ltd., Sunbury-On-Thames, Middlesex, England. *(ASLE Paper No. 61LC-9)*

"Preparation, Properties, and Some Applications of Super-Refined Mineral Oils," by E. E. Klaus, E. J. Tewksbury and M. R. Fenske, Pennsylvania State University, University Park, Pa. *(ASLE Paper No. 61LC-10)*

"Dynamic and Static Irradiation of Nuclear Power Plant Lubricants," by D. B. Cox, E. A. Oberright and R. J. Green, Socony-Mobil Oil Co., Paulsboro, N.J. *(ASLE Paper No. 61LC-11)*

"Viscous Lubrication in Wire Drawing," by J. F. Osterle and J. R. Dixon, Carnegie Institute of Technology, Pittsburgh, Pa. *(ASLE Paper No. 61LC-12)*

"Effects of Base Oil Viscosity and Type on Bearing Ball Fatigue," by F. G. Rounds, General Motors Corp., Warren, Mich. *(ASLE Paper No. 61LC-13)*

"The Effect of Contact Angle on Rolling Contact Fatigue and Bearing Load Capacity," by E. V. Zaretsky, W. J. Anderson and R. J. Parker, NASA, Lewis Research Center, Cleveland, Ohio. *(ASLE Paper No. 61LC-14)*

"Weibull Distribution of Rolling Contact Fatigue Life and Deviations Therefrom," by T. Tallian, SKF Industries, Inc., Philadelphia, Pa. *(ASLE Paper No. 61LC-15)*

"Evaluation of Ball Bearing Performance in Liquid Hydrogen at DN Values to 1.6 Million," by H. W. Scibbe and W. J. Anderson, NASA, Lewis Research Center, Cleveland, Ohio *(ASLE Paper No. 61LC-16)*

"Lubrication of Rolling Surfaces by a Ree-Eyring Fluid," by J. C. Bell, Battelle Memorial Institute, Columbus, Ohio. *(ASLE Paper No. 61LC-17)*

"The Design of Externally Pressurized Gas Thrust Bearings for Maximum Stiffness and Stability," by D. C. Allais, IBM Research Laboratory, San Jose, Calif. *(ASLE Paper No. 61LC-18)*

"Pressure and Flow Studies of an Experimental Externally Pressurized Gas Lubricated Bearing," by G. B. Speen, ITT Federal Laboratories, San Fernando, Calif. *(ASLE Paper No. 61LC-19)*

"Analysis and Design of Externally Pressurized Gas Bearings," by I. Tang and W. A. Gross, IBM Research Laboratory, San Jose, Calif. *(ASLE Paper No. 61LC-20)*

PERSONALS

Curry E. Ford has been named director of development for National Carbon Company, Division of Union Carbide Corporation. Mr. Ford joined National Carbon in 1937, and was active in the development of carbon and graphite chemical process equipment.

In 1953 he was named manager of chemical products sales. He was appointed new products marketing manager in 1957, and since February, 1960, has been director of marketing.

Gregory P. Cordones, Neptune, N.J., has joined the sales force of the Joseph Dixon Crucible Co., Jersey City, N.J. He will represent the company's paint, graphite and lubricants divisions in the state of New Jersey.

G. P. CORDONES

J. B. SMITH

James B. Smith, manager of lubrication and commercial sales for the Esso Standard Eastern Region, Humble Oil and Refining Company, has been named coordinator of lubricating and process oil sales in the new headquarters marketing department of Humble in Houston, Texas.

Retired Lubrication Engineer Enjoyed 1600 Mile Boat Trip

Mr. and Mrs. Frank L. Gray, formerly of Gary, Indiana made the 1600-mile trip from upper Lake Michigan aboard their own houseboat to Lake Buchanan, near Beaumont, Texas.

"We wanted to do something that we'd never done before when we retired." Gray said. It all started when Mr. Frank L. Gray retired recently as a lubrication engineer with the Gary Steel Works of U.S. Steel. "I went to work at a temporary job in the steel mills after being discharged from the service following World War I," he said. That temporary job lasted 41 years.

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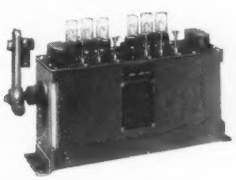

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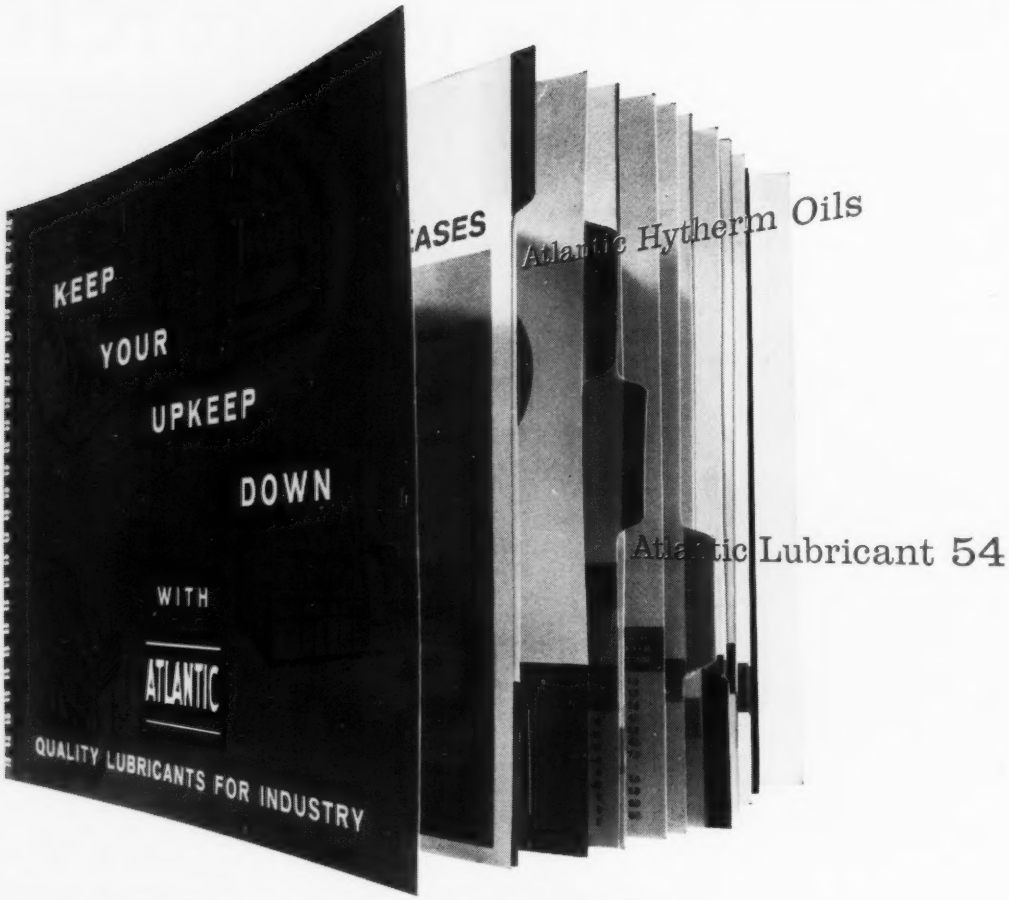

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The valuable 60-page booklet shown above is *free* to lubrication engineers and purchasing agents. It puts complete information on all Atlantic greases and oils at your finger tips. For your copy, simply write The Atlantic Refining Company, 260 South Broad Street, Philadelphia 1, Pa., giving your title and company name. We'll see that a booklet reaches you without delay.

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SECTION NEWS

Milwaukee—Mr. R. G. Pendleton, Humble Oil and Refining Co., will discuss "Petroleum Pipeline: Installation and Operation" at the November 16, 1961 meeting. December 11 has been designated as Monte Carlo Night.

Philadelphia—On November 16, the Section will conduct a tour of the Franklin Institute Laboratories, beginning at 3:00 p.m. The group will adjourn to McCallister's for a social hour and dinner. After a short business session, Mr. Harry C. Rippel, Franklin Institute Laboratories, will discuss "Bearing Design and Role of Lubrication."

Central Ohio—A tour of Kaiser Aluminum, Newark, Ohio is scheduled for November 27, 1961. There will be no Central Ohio Section meeting in December.

Twin Cities—The October 26, 1961 meeting entailed a Field Trip to the REA Atomic Plant.

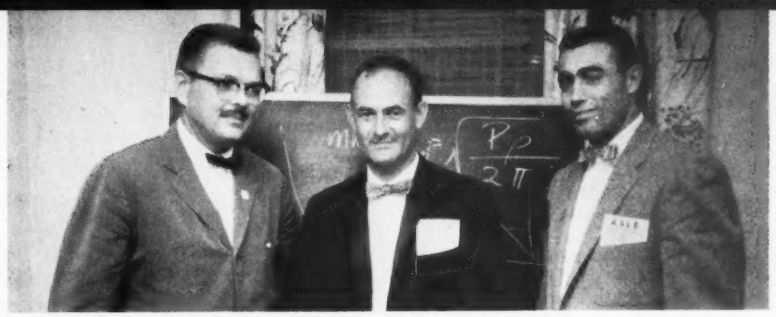
Baltimore—The November 9, 1961 meeting will feature Mr. R. K. Ulrich, Lubrication Engineer, Bethlehem Steel Co., Steelton Plant, who will discuss "Lubrication Features of the 11" Bar Mill."

Boston—The November 20, 1961 meeting will be held at the M.I.T. Faculty Club, when Dr. William Campbell will speak on "Solid Lubricants."

New York—More than 70 members and guests were in attendance at the New York Section's first fall meeting. The guests included Bill Sentner, Past Chairman of the Boston Section, and Doc Dougherty, Past Eastern Regional Vice President. Mr. J. L. McGinnis, Enjay Chemical Co., lectured on the present and probable status of lubricant types, and the method and frequency of application of present and probable future automotive equipment.

Los Angeles—Mr. Charlie Pope, Lubrication Engineer at Eastman Kodak for thirty years, highlighted the October 18, 1961 meeting. His subject was "Ramifications of Industrial Plant Lubrication."

Pittsburgh—"Coolant Applications" were discussed at the November 9, 1961 meeting by Mr. Joseph E. Kessler, General Sales Manager, Van Straaten Chemical Co. The Pittsburgh Section will celebrate their Christmas Party on December 14, 1961.



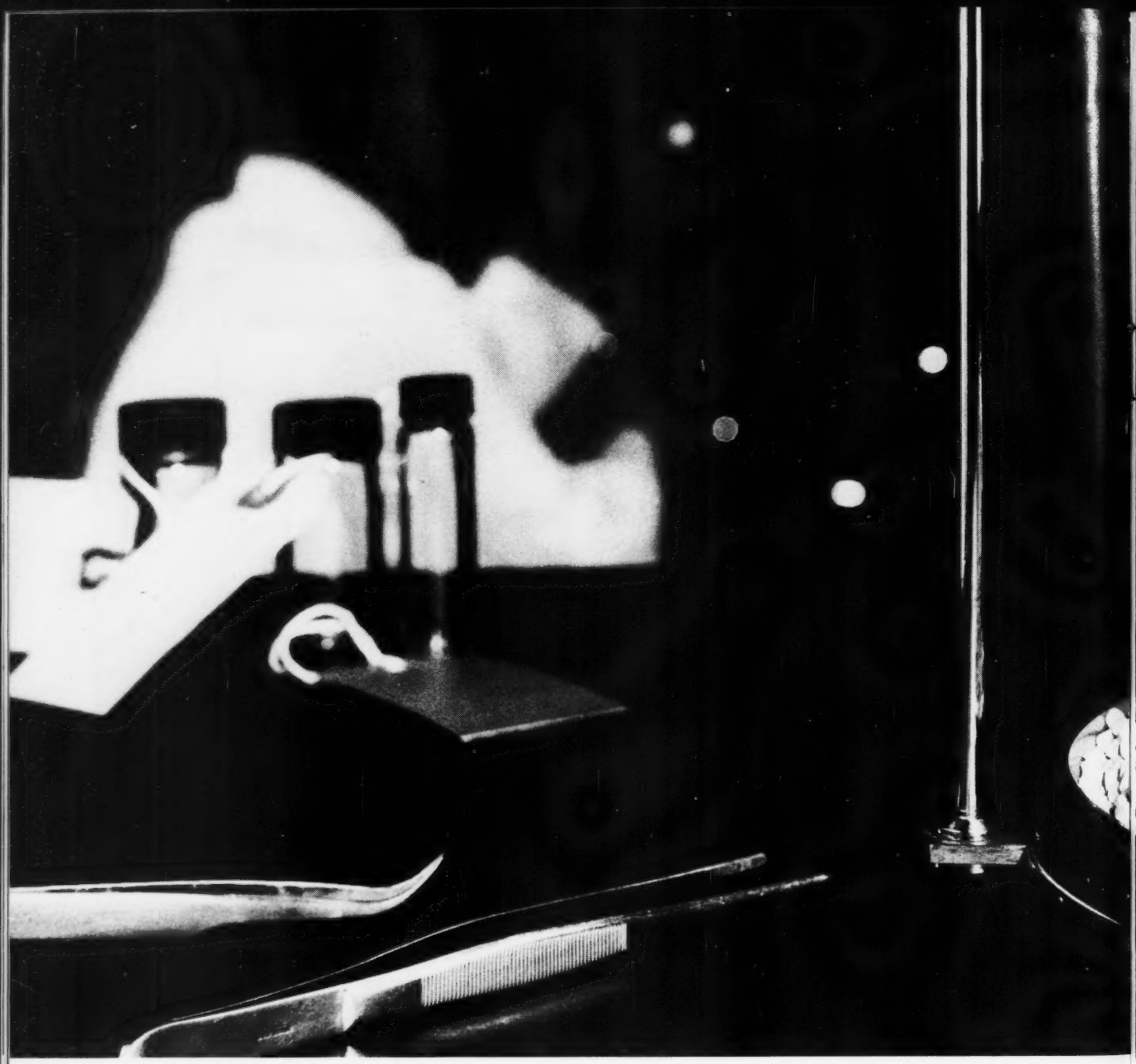
Fifty members and guests turned out for the Boston Section's meeting on October 2, 1961 to hear Dr. Earl Jackson speak on "Space Lubrication." Pictured above are (left to right): Mr. C. S. Mercer, Member of ASLE National Board of Directors; Dr. Earl Jackson, Member of ASLE National Board of Directors; and Mr. A. B. Celi, Chairman of the Boston Section.

New York Section Officers (left to right): S. G. Harris, program Chairman; E. M. Strom, Section Chairman; M. H. Zitkow, Secretary; A. E. Van Schoick, Treasurer; and R. L. Moy, Membership Chairman.

J. L. McGinnis, is shown lecturing at the October meeting of the New York Section.

The Detroit Section of the ASLE opened its fall season on September 19 with a truly fine showing of the membership. Mr. E. W. Fisher, Technical Coordinator of Military Products for Garlock, Inc., was guest speaker. He outlined the recent advances made in oil seals and problems associated with them in his talk entitled "Seals and Compatibility with Significant Laboratory Tests."

The photograph (below) shows, from left to right, David Hill of Rockwell-Standard Corporation, Chairman of the Detroit Section of ASLE, E. W. Fisher (center), and Dr. A. DiGuilio, representing the ASM.



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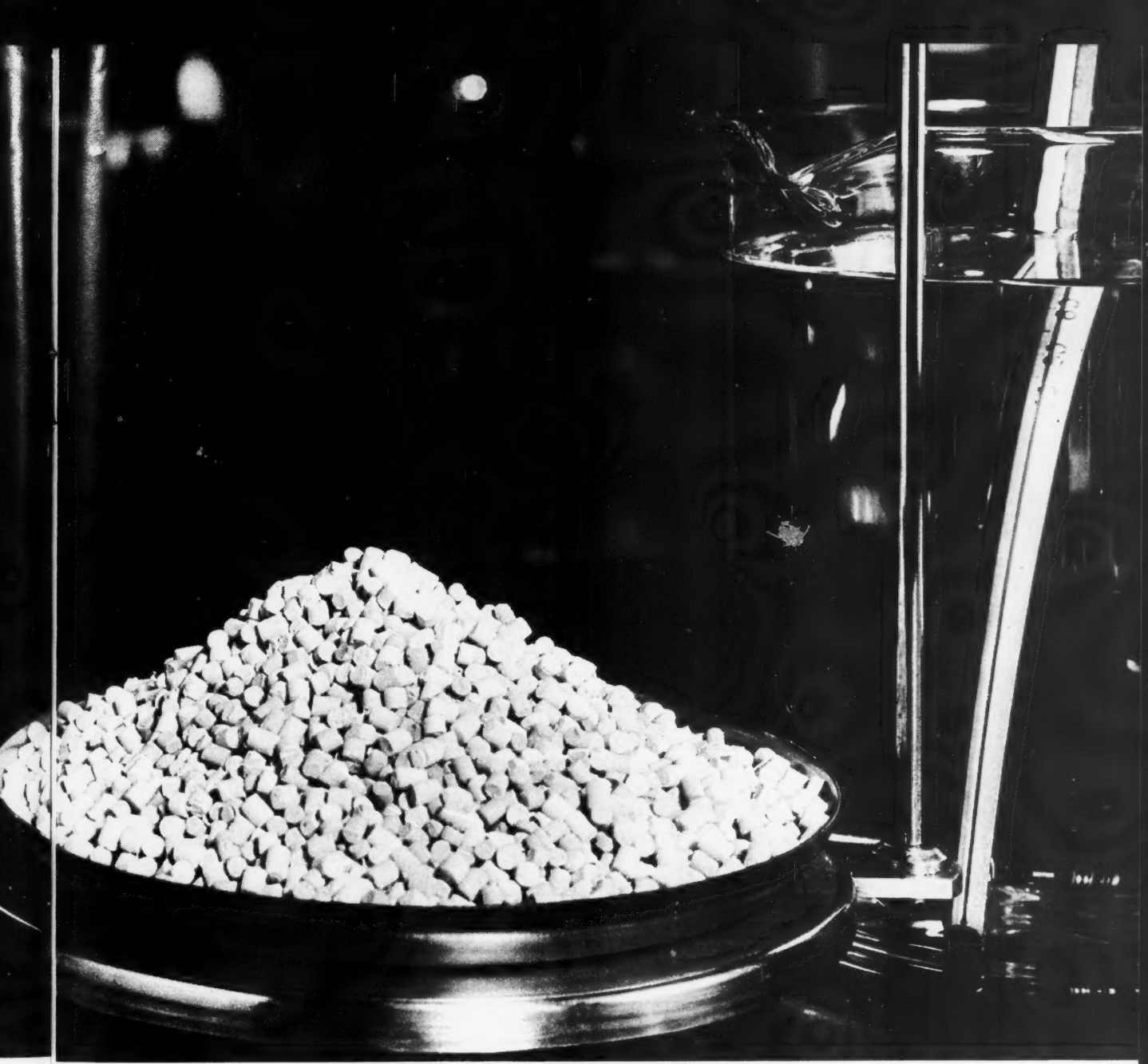

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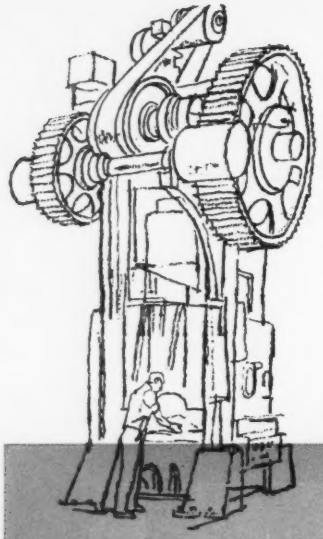


Editor's note: Developing steadily over the past 15 or 20 years, Lubrication Engineering has emerged as a distinct and mature branch of modern industrial technology. Further, careful analysis of a number of highly effective *Lubrication Engineering* operations has revealed certain recurring factors that seem fundamental to good results. This article has been prepared to outline these "common denominators" of successful lubrication engineering.

Three "Musts" for an Effective LUBRICATION ENGINEERING *Program*

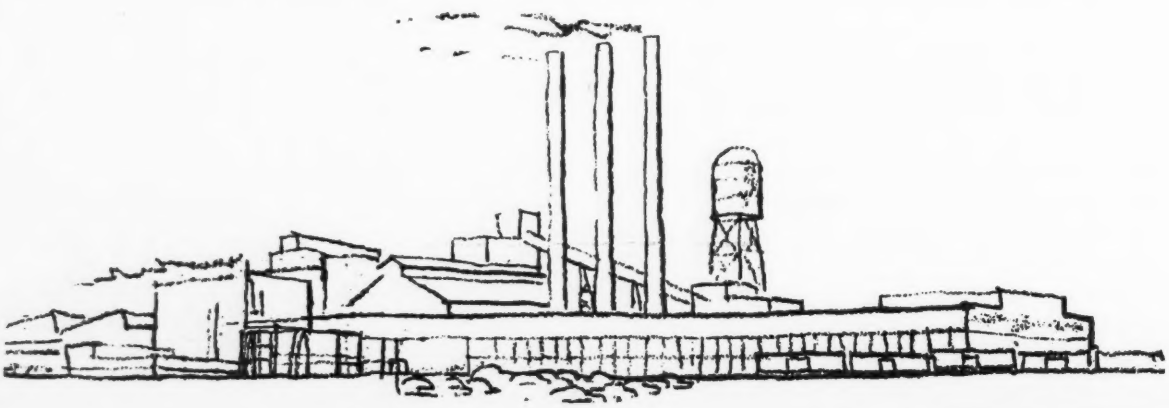
At the operating level, in almost every branch of industrial science, too much valuable time is lost in solving an endless succession of emergency problems. This preoccupation with just keeping the old system going prevents, or at least hampers, efforts to improve the system itself.

Lubrication engineering is no exception. All too often, instead of being concerned with increasing over-all operating efficiency and decreasing costs, the lubrication engineer is forced to function as a sort of "maintenance vigilante"—rushing from hot bearing to hot bearing with never a moment to concentrate on the important business of prevention.

It is no coincidence that lubrication engineering programs wherein this "endless emergency" cycle has been broken are among the most successful in the country—or that such successful programs are all based on the same essential fundamentals of administration.

Reduced to their simplest terms, these fundamentals comprise the three "musts" of an effective lubrication engineering program. They are:

A. Establish well defined procedures.
B. Adhere to detailed schedules.
C. Upgrade lubrication personnel.



Before going on to discussion of these "musts", however, two observations must be made. First, they are not merely suggestions or recommendations. Rather, they are the result of careful analysis and represent a factual summary of the factors actually found to be important in the majority of successful operations.

Second, while application of these fundamentals would seem essential to a successful lubrication engineering program, they do not by themselves guarantee success. How they are applied makes a great deal of difference, and they must be applied differently in virtually every situation.

No attempt to lay down a formula is intended here. The purpose of this article is simply to discuss the operating ground rules that assure maximum return for engineering effort expended.

ESTABLISH WELL DEFINED PROCEDURES

Inconsistent, haphazard action is a major source of lubrication difficulty. Cognizance of all phases of lubrication activity is necessary to eliminate this difficulty. And only well defined procedures covering selection and specification, procurement, receiving inspection, storage, application and disposition will assure such cognizance.

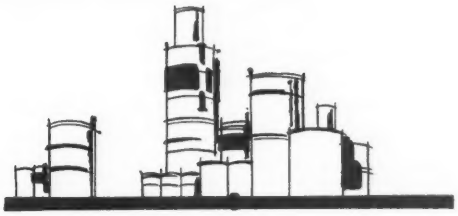
Selection and specification of lubricants and lubricating equipment are particularly important but is usually easy to establish. In most cases, authority in this area is a basic part of the lubrication engineering mandate proceeding directly from top management.

As for procedure, lubrication engineering initiation or approval of all purchase requisitions involving lubricants or lubricating equipment is the most common approach. The primary objectives of this type of procedure are to assure the adequacy of all materials in use and to reduce the number of different materials used. Some of the largest operations analyzed are very nicely covered by only 3 to 5 different greases and 10 to 15 different oils, including hydraulic media.

Actual *procurement* is a somewhat more delicate matter because source preferences, prices and such intangibles as service and availability are often involved. In most cases, the procedures established in this area are based primarily on close cooperation with those actually charged with the purchasing responsibility.

Closely connected with procurement procedures are those provided to cover *receiving inspection* and the insurance of quality standards. Here, on technical grounds, sources may be approved or disapproved and all shipments should be subject to examination by the lubrication engineer prior to acceptance.

Although actual methods for monitoring sources and material quality vary widely, a sampling procedure is almost inevitable. The samples may be retained as a record for subsequent study if some question arises or, if laboratory facilities are available, will be processed prior to entry of the material into storage.



Once material has been selected, procured and accepted in accordance with consistent procedure and under careful control, the most obvious area of concern for a lubrication engineer come under consideration. These are the storage of lubricant materials for use and the proper application of these materials.

Proper *storage* procedure and control hinge on a separate lubricant storage area. Where the area is and what it consists of are not so important as that it be separated from routine plant traffic. This is essential in order to limit access to authorized personnel only and to minimize the hazards of unintentional contamination or mixing of materials.

Other cogent reasons for separating the lubricant storage area are: (1) to decrease fire hazard and insurance costs, (2) to facilitate stock record keeping and inventory surveillance and (3) to permit installation of handling and measuring equipment as required.

Before leaving the subject of storage, the closely related business of disposing of used up or exhausted lubricants should be mentioned. Providing that sufficient quantities are involved, significant economies can be achieved through reclamation of used lubricants for use in less critical applications. And even where no re-use opportunity exists, controlled disposition procedures provide the best possible assurance against the false economy of over-use.

Application procedures are probably the most vital of all. These provide the greatest opportunity for operating improvement, have the most direct effect on results and vary the most. Virtually every plant will call for a different approach.

Yet, despite the almost unlimited variation in application procedures, the right system for a given plant is almost certain to evolve from attention to three key elements. These are methods of application, the schedule of application and application personnel.

Schedules and personnel are of such overriding importance in successful lubrication engineering that they will be treated separately in this discussion of practical fundamentals. Methods are almost equally important but lend themselves to briefer treatment because their determination is usually a straightforward matter of meeting the needs of the equipment on hand as efficiently as possible.

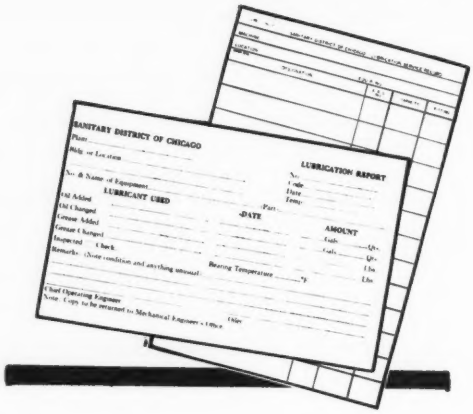
Automatic lubricant dispensing and metering devices, to reduce requirements for direct attention to a minimum, are applied wherever economically and mechanically feasible. Mobile supply carts of one kind or another are also quite universally used to facilitate the actual movement of lubricants from storage to the point of application. In general, the principal criteria

for selecting methods of application are man-hour conservation and minimizing error.

The final consideration under the heading of procedure is a system of *record keeping* of some sort. Naturally, such data as quantity consumed, costs and sources are recorded as a matter of routine. But even more vital are records that tie directly to the economics and advantages of lubrication engineering.

It is these records that enable management to make proper evaluations of the total program. Such items as decreasing incidence of equipment failure, decreasing man-hour requirements and increasing productive capacities through improved lubrication practices are especially noteworthy. And to be certain that such statistics come to the attention of management, they should be included in regular operating reports. It is surprising how documented evidence of cost reduction can make an appropriation request look like a sure fire investment instead of a doubtful expenditure.

In summary, selection and specification, procurement, storage and handling, disposition, application and record keeping — are the principal areas in which clearly defined procedures have been found essential. Virtually without exception, successful lubrication engineering programs provide for control in these areas. Actual methods vary widely to suit specific situations, but whatever is done is done consistently and as planned.



ADHERE TO DETAILED SCHEDULES

Good scheduling is the real "clincher" in lubrication engineering. It sets out the *what, wher and when* of actual lubricant application and even though the schedule itself is probably the most individual and highly customized phase of any lubrication program, it must be based on meeting three fairly obvious requirements.

LEGEND

A.P. —ALEMITE FITTING
H.O. —HAND OILED
B.B. —BALL BEARINGS
R.B. —ROLLER BEARINGS
P.B. —PLAIN BEARINGS
M.O.L. —MAINTAIN OIL LEVEL
H.P. —HAND PACK
N.B. —NEEDLE BEARINGS
W.P. —WASTE PACKED
S.F. —SIGHT FEED OIL CUP
W.P. —WICK FEED OIL CUP
G.C. —GREASE CUP
R.O. —RING OILED
B.O. —BATH OILED
A.N.F. —BUTTON HEAD FITTING
F.F. —FORCED FEED
R. —RESERVOIR
C. —CIRCULATING

LUBRICATION SCHEDULE

AUTOMATIC CAP LINING MACHINE

DEPT. SUNDRIES

BLDG. 135 FLOOR GROUND

Surveyed by Halter - Torrens Date 7/29/60

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Page 1 of 1 Pages

Location on Floor	Equipment	Item No.	Parts to Be Lubricated	Type of Brgs. or Gears	Method of Lub.	S.K. Lub.	Frequency of Lub.	Frequency of Inspection	COMMENTS
	SORTER		Motor	B.B.	Plug	2028	Yearly	Weekly	Clean & repack every 6 years.
			Worm & Worm Gear	-	B.H.F.	2040	Weekly	Weekly	Keep housing filled with grease.
	CAP LINER		Motor	B.B.	Plug	2028	Yearly	Weekly	Clean & repack 6 years.
			Gear Reducer	Spur	B.O.	1600	M.O.L.	Weekly	Drain & refill 2 years.
			Variable Sheave Brgs.	P.B.	A.F.	2028	Monthly	Weekly	
			Drive Chain	Roller	Brush	2040	Monthly	Weekly	
			Open Gears	Spur	Brush	2040	Monthly	Weekly	
			Misc. Bushings	P.B.	B.H.F.	2040	2/Week	2/Week	
			Vacuum Chuck Bushing	P.B.	H.O.	1600	M.O.L.	Daily	Keep oil cup filled.
			Chuck Cam Shaft	2 P.B.	H.O.	1600	2/Week	2/Week	
			Table Ways	-	H.O.	1600	2/Week	2/Week	
			Yoke	P.B.	B.H.F.	2040	Monthly	Weekly	
			Chuck Cam	-	Brush	2040	Monthly	Weekly	
			Transfer Arms	-	H.O.	1600	Monthly	Weekly	Few drops in oil cups.
	VACUUM PUMP		Pump	2 P.B.	H.O.	1600	Weekly	Weekly	Few drops in oil cups.
	AIR LINE		Lubricator	-	-	1600	Keep Lubricator Filled		
	CONVEYOR		Drive Motor	B.B.	Plug	2040	Yearly	Weekly	Clean & repack 6 years.
			Gear Head	Worm	B.O.	1600	M.O.L.	Monthly	Drain & refill 2 years.
			Flange Cartrg. Brg.	6 B.B.	A.F.	2028	6 Months	Weekly	
			Drive Chain	Roller	Brush	2040	Monthly	Weekly	
			Oven Conveyor Chain	-	Lubricate with Silicone Oil -- As Needed.				

The first of these is complete coverage. Each piece of equipment, and all of its specific needs, must be included in the schedule. Production machinery, of course, is always a primary subject for lubrication attention, but mobile equipment and service units such as fans and life mechanisms (and the transport cart used by the lubrication staff, too) are often neglected. Failures here can be just as troublesome and costly as actual production equipment shutdowns.

To meeet this first requirement, complete coverage, the usual approach is a physical survey. In some cases, existing capital equipment records will be helpful as a check but they are rarely sufficiently detailed for the purpose of establishing a lubrication schedule. It is also important to provide for the inclusion of a running log or history of lubrication attention and for subdivision of the over-all list into groups by type of equipment or area of location. Individual cards of sheets for each item surveyed are most commonly used.

But there is more to assuring completeness of the application schedule than the initial survey. Provision must be made for the addition of new equipment to the record, and, detailed instructions concerning the specific requirements of each piece of equipment must be included. These instructions should call out materials needed, means and quantity of application and frequency of application.

The next basic application schedule requirement to be satisfied, once complete coverage has been assured, is to simplify the task of following the schedule in such a manner as to make it practical. Detailed procedures established for this purpose are strictly tailored to suit the situation, but all will involve careful "route planning" to service the greatest possible number of units with the least effort. Good "route planning" of the lubrication schedule assures that each piece of equipment will receive individual attention as frequently as possible within the capabilities of the lubrication staff and that the attention will be complete and correct.

Copies of the basic lubrication survey, if properly prepared, can serve this purpose. Issued to lubrication personnel in preselected sections and arranged in correct order, the survey cards or sheets will tell where to start, where to go next and what to do at each stop—giving the lubrication engineer complete control of the entire application process. Color identification or labelling of lubrication application points to designate type and frequency of lubricant application has also proved useful in this connection.

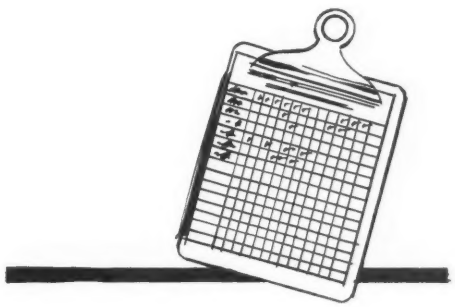
Automation of the whole process of lubricant application is, of course, an even more fundamental answer to the problem of following the established lubrication schedule. Centralized systems requiring little or no operator attention are increasing in popularity. But in the final analysis, whether or not to use an automated system is an engineering determination in itself. The means of adhering to the schedule may be changed but the basic responsibility for getting it done does not.

After a schedule has been worked up to the point where complete coverage and reliable execution are assured, the final requirement is provision for maintenance of efficiency. Any system, however well conceived, will tend to deteriorate with the passage of time.

Therefore, to assure quick recognition of trouble signs and immediate diagnosis of any deterioration or error in the system, reference to records of previous activity must be available. These records constitute an efficiency report on the performance of the lubrication function and regular inspection of entries is a sure way to make sure that the schedule is being followed.

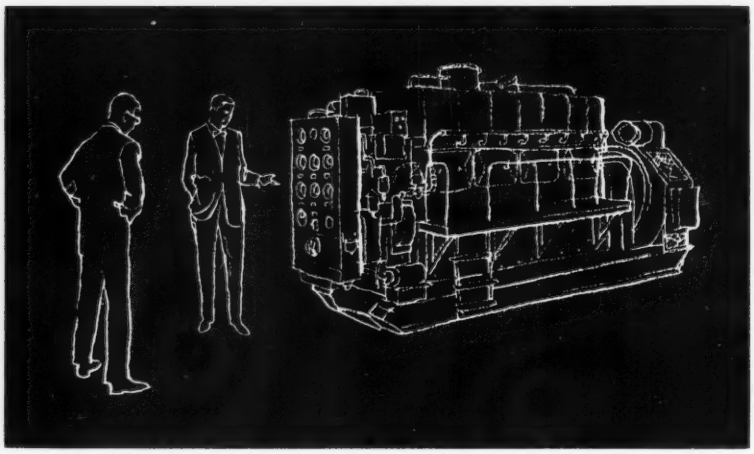
Methods for keeping these follow-up records range all the way from simple check-off sheets to complete report systems with special forms to be filled out and filed each time a given piece of equipment is serviced. But whatever the method, the schedule is tied directly to results and failures if they occur. It must be so to have real meaning.

Thus, the important requirements of scheduling are complete coverage, practical arrangements for following the schedule and a system of follow-up to guarantee continual efficiency. But even with these requirements met, any program can still founder on the shoals of personal indifference or ignorance on the part of the men who do the work. No system can be any better than the men who use it—and this leads to the final commandment of effective lubrication engineering.



UPGRADE LUBRICATION PERSONNEL

The first step in upgrading the lubrication worker is to upgrade the job itself. Measures should be taken to make lubrication safer, more thorough and, above all, cleaner. As in the case of the sewer digger who termed himself a sanitation specialist, attitude can make a world of difference in performance—can turn a transient and indifferent greaser into a steady and dependable lubrication technician.



But the greatest gains in this area are made via training programs aimed directly at improving the men themselves. Response to such opportunity will be surprisingly eager and quick to show up in efficiency.

Regularity in such training programs, plus continual emphasis on the "whys" of lubrication as well as the routine "hows", is of the essence. In addition to being in accordance with sound teaching procedure, regularity carries an implication of future betterment and stability that will help to hold good men. Explanations of the reasons of various lubrication activities conveys the sense of purpose that is essential to real job satisfaction.

Upgrading lubrication personnel will produce some surprises too, in the form of benefits far beyond simple increases in the efficiency of the lubrication operation. First, the lubrication staff becomes an alert and interested intelligence group operating in all areas of the plant to provide a continuous flow of good information on basic equipment condition—a great boon to preventive maintenance.

Well defined procedures, strict scheduling and enlightened personnel development, then, are three commandments of effective lubrication engineering. And there's far more to be gained from the application of these commandments than just the reduced costs and smoother operation that will signify success to plant management. Indeed, a whole new concept of the lubrication engineering function develops, based on "4 freedoms" that would not otherwise exist.

The first of these is freedom from the frustration of solving a never ending succession of unnecessary problems. Instead, the program functions to prevent trouble, to forestall problems.

The second freedom results from the first. Time saved by avoiding petty problems gives the lubrication engineer freedom to concentrate on basic improvements in his program . . . through study, special experimentation and even research.

Freedom to expand his sphere of influence is the third. Logical avenues for this type of expansion are into equipment design (solving lubrication problems before they are built-in) and into the broader areas of general plant maintenance. Whereas lubrication costs alone usually run below 1% of operating costs, overall maintenance often exceeds 10% and is subject to the same sort of attack that will work on lubrication problems.

The last of the 4 new freedoms for lubrication engineers, and perhaps the most important in the long run, is freedom to contribute. Without good procedures, good schedules and good men, the harassed plant lubrication engineer is usually too busy to even read papers, much less prepare them. Yet his knowledge, and the knowledge of thousands of others like him, comprises the real body of lubrication engineering science. This knowledge must be exchanged.

In closing, it must be pointed out again that the foregoing is not a series of recommendations or suggestions. Rathers, the three "musts" of plant level lubrication engineering, as presented here, are based on an analysis of what is actually going on where lubrication engineering is working the most successfully. To apply these fundamentals in any lubrication engineering operation is like filling the pool before taking diving lessons . . . a very sound first step!

BULK GREASE HANDLING

by A. C. Gartley
Sales Engineer
American Oil Company
Chicago, Illinois

The paper "Bulk Grease Handling" is a short history of this subject from a supplier's point of view. It gives a brief background of events leading to the lubricants suppliers need to develop suitable equipment for transporting grease from his grease works to the customer's storage tanks. It is shown that miscellaneous problems unique to the customer and supplier dictate the type of equipment used to transport grease.

Competition, along with recent trends for developing and perfecting new facilities and techniques, require a detailed appraisal of operations for handling grease in bulk quantities.

A number of installations in the past few years prove the value and feasibility of bulk grease handling. Consequently, with the pioneering work nearly completed, the pattern for the future is clearly outlined. The supplier or customer who fails to avail himself of the new methods soon will find himself losing out.

There still are some problems to be solved, however. After a relatively slow start, it appears that solutions to most of these problems will be solved soon, at least to the extent that bulk handling of grease will become the general practice, rather than the exception, if, indeed, it is not already.

The Steel Industry has undoubtedly spearheaded the present trend to bulk handling. This bulk handling, however, was preceded by the evolution of lubricants in the mills, and the application of these lubricants where needed.

In the 1920's, black oil was commonly used as a general mill lubricant. The oil was delivered to mill central storage by tank car. From there it was trucked to the operating departments and hand applied to the machinery. Some oil and grease cups were used, but they were relatively unsatisfactory. Also during this period, grease fittings and pressure hand grease guns were developed. These were an improvement over the grease cups, but were not satisfactory from a safety standpoint. Then, too, there was no accurate control in dispensing the lubricant.

In the 1930's, centralized lubrication systems began to gain stature and hand oiling declined. Black oils were gradually replaced by greases which could be used in central systems. These greases, using various base soaps, were delivered to the mills in containers of miscellaneous sizes and shapes. The multiple varieties of greases and sizes of containers created an inventory problem and the very real problem of using the wrong product.

Presented at the 16th ASLE Annual Meeting in Philadelphia, Pa., April, 1961

Fortunately the oil companies were aware of the problems involved, and in the 1940's began to introduce multi-purpose greases. Also, standardization of container size was accepted and the 400 pound drum become the accepted large-size grease container.

These developments, multi-purpose grease and standard-size containers, helped the situation tremendously, but did not eliminate handling problems. The oil companies moved car loads or truck loads of grease drums into the mills, and usually unloaded at an oil storage area. Large inventories of 400 pound drums of grease were (and still are) maintained in central storage areas. As needed, the grease is then sent out to the consuming department. The saga of the journey of a drum of grease to a typical steel mill runs like this: The grease is filled into drums at an oil company's grease works, the drums are loaded into a carrier for delivery to a mill, the drums are unloaded, and stock piled at the mill's central oil storage. As needed, the drums are loaded into carriers and moved to the consuming department's storage area, where they are unloaded. Then, as needed, they are loaded and moved into position for dispensing the grease into various systems. When the drum is considered empty, it is moved to the department's empty drum storage area. It is then loaded into carriers and is moved to the mill's salvage yard, unloaded, stock piled and eventually loaded into carriers for destinations outside the mill.

This shows that grease drums are handled a great many times in most steel mills,—averaging eight times. There is the possibility of spillage, leakage, and grease being left in the drums when dispensing. As much as 10 percent is left in the drums, which is a costly waste.

As is usual with an undesirable situation, it becomes necessary to find improved methods. Early in the 1950's, some of the men in the steel industry began to think of bulk grease handling. Interest was aroused, and some preliminary work was done. About 1953, a major oil company gave a large steel producer a set of drawings of a proposed bulk grease trailer. This amounted to a tank on wheels which could be filled at a grease works, pulled to the customer's location, and grease could then be pumped from the unit as an integral part of the dispensing system. This would necessitate more than one unit. The seed of bulk handling was planted, but for a few years no actual system was put into operation in the Steel Industry.

Peculiarly, about the same time the steel industry was considering bulk handling, a coal company got into bulk handling, probably through economic necessity. This was in 1955. This company had a large installed tank which they could divert to grease storage. They were using a double "0" grade of grease. Their supplier agreed to haul grease to them in bulk, and has been doing so for the last five years, moving the grease in a transport truck similar to one used for moving fuel oil. In this case, necessity caused them to solve their problem with a minimum of conversion.

From about 1955 on, the Steel Industry evinced an increasing interest in bulk grease handling. In the early 50's some of the pioneers could see the desirability, but after 1955 the real need became apparent. Competition and rising expenses created an urgent need to cut costs. Incentive programs made everyone cost conscious. Therefore, in looking at ways to save money, the ever present problem of costly handling of lubricants came to the attention of many groups. Bulk grease systems were designed for old as well as new installations. New construction naturally took priority in getting bulk facilities, because of available funds.

During this early phase of bulk grease system design, it seemed desirable for the mills to construct systems in which the grease tanks could be moved from the dispensing location to the supplier's grease works or source of supply, filled and returned to the customer's mill. Some systems of this type were designed and at least two were put into operation.

The first bulk grease handling facilities in the Steel Industry in this country were installed in a universal slabbing mill of a Midwestern steel company near Chicago. Here three 4,000 pound portable containers are manifolded in central storage. Each container is 4 feet in diameter by 6½ feet in height, and is fabricated from ⅜ inch steel plate, reinforced with steel ribs with the bottom made of ¾ inch plate. The entire assembly, except the cover, is welded together to form a single unit. A ¾ inch plate cover is bolted into position. A special feature on this tank is a pneumatic follower plate. An inflatable seal on the follower plate enables atmospheric pressure to provide positive pump prime; the seal also wipes the tank walls clean during each emptying cycle. The 2-inch pipe, used as a guide and level indicator, is removed when shipping a filled container. Containers are filled and emptied through a single line and valve at the bottom of the tank. At one time, the tanks were taken from the building through removable hatch covers, placed on a flat bed truck, and taken to the supply source.

Probably the first bulk container used by one of the largest steel companies was at their Sheet and Tin Mill. It is a square tank of about 4,000 pound capacity, fabricated by their roll shop. A later design is the round portable tank of 5,000 pound capacity. This tank has a diameter of 54 inches, and a height of 60 inches; the stand is 30 inches. An air-driven pump is mounted on top of the container. This tank does not incorporate a follower plate because experience shows no residuary grease remains in the container. Currently these tanks are moved by flat bed truck to the supplier's warehouse for filling.

After the first installations and while subsequent installations were being designed, a second phase of bulk handling evolved. It became apparent that it would be desirable and necessary to put the storage tanks permanently in position as an integral part of the dispensing systems. Location and space problems dictated this.

At this time, this same steel company was designing several new facilities. One of these was a 46-inch slab mill, which is now in operation. A central grease system with a 20,000 pound tank for grease storage was part of the installation. The tank located in the basement is filled from the top. A 4-inch fill line 390 feet long electrically traced leads to the outside of the building.

Since this installation at the 46-inch slab mill, at least three more systems were installed at the same steel works. All of these use tanks of about 4,000 pound capacity.

The new coal handling facility at this steel company has 3—4,000 pound grease tanks. They normally receive bulk grease in 8,000 pound quantities.

The Sinter Plant at this steel company has 1—10,000 pound tank, and usually takes 8,000 pound loads of bulk grease per delivery.

The 12-4 mill at this same plant has 2—4,000 pound tanks and takes loads of approximately 7,000 pounds per fill.

While all of this design and installation of equipment was being accomplished in the various steel mills, the grease suppliers were attempting to work out suitable methods of delivering grease products to their customers. The problem became unique to the supplier involved with each installation. If the supplier was currently furnishing to a mill which was converting to bulk handling, it became necessary for him to develop a means of delivery or bow out of the picture. Also, the location of his grease works, number of customers involved, and future potential business helped to determine the type of equipment needed to move grease to the customer.

Temporarily, at least, some oil companies have not entered the delivery of bulk grease. It is to be assumed that they will decide to enter this type of operation at some future time.

One of the major oil companies, as grease supplier for the aforementioned steel company's 46-inch slab mill, decided to have a large grease transport designed and built. This unit built on a trailer contains two vertical tanks, each having a 12,500 pound capacity. These tanks use a patented follower plate for pushing grease to the 4-inch lines in the bottom of the tanks. Grease is pumped off at the rate of 100 gallons per minute at 120 degrees Fahrenheit.

At the time of the writing of this paper, this oil company was building a second, three-tank unit with 40,000 pound capacity.

Two large oil companies have converted tank wagons for hauling bulk quantities of grease. These units can haul maximum loads of about 15,000 pounds each. With some changes of valves, piping and pumps, these units do a remarkably efficient job. Naturally the economic efficiency of these units depends on a source of supply near the customer's plant, making short hauls practical.

Another large oil company, with its grease manufacturing plant in New Orleans, decided to use rubber bags. These can be shipped to their local warehouses in a given area, and moved from there to the customer's plant by truck. In the Chicago area they are using 4,000 pound bags which they move from their warehouse to the customer's plant by flat bed truck, three bags to a truck. These bags are unloaded by a geared pump through 3-inch lines.

This company is currently offering to supply one steel customer with bulk grease, using these bags as customer storage. They will deliver a bag, set it into a cradle from where it can be pumped as needed, into the customer's grease system.

Still another large supplier has or will have two units operating out of Pittsburgh. These are vertical tank units with a total capacity of about 32,000 pounds.

One of the above-mentioned companies has experimented with the use of public carrier transports. With some relocation of pumps, grease can be successfully moved by this method. This, of course, is economical because equipment can be used for more than one product if care is used in cleaning the tanks.

Early in December of 1960, an automobile manufacturer put a large-scale grease dispensing system into operation. Their two tanks hold 80,000 pounds of grease. The suppliers had preliminary problems to solve on their first deliveries to this installation, but deliveries are now routine. Suppliers are currently hauling bulk grease as far as 400 miles to this plant.

The above illustrations of plant bulk grease installations proves the practicability of this type of operation for industry. The illustrations of various methods of delivering bulk grease show that grease suppliers are giving serious consideration to this phase of the problem.

Manufacturers of tanks and grease dispensing equipment have been and are keeping abreast of the trend, proving that bulk grease dispensing is here to stay.

The grease suppliers have a unique problem. They must design and build equipment for transporting grease based on the following considerations:

1. Location of their grease manufacturing facilities.
2. Number of bulk grease customers or potential customers.
3. Capacities of the customer's bulk grease systems.
4. Types of Greases involved.

Each supplier must evaluate these problems and design his equipment to satisfy the customer's needs efficiently, economically, and with a fair profit for his company. The grease suppliers have taken and are taking a good look at grease transportation. Some interesting and practical methods of transporting grease are now in operation, and the future will see improvements on these as well as new types put into use.

When all this is accomplished, the end result is a smooth flow of grease from the maker's kettle into a large container for transporting to some customer's bulk grease containers. The grease is moved to the customer's tanks from supplier's tank with a minimum loss of product, time, and labor, and very little chance of contamination. The operation becomes essentially simple as compared to the outdated movement of grease by drums.

Bearings *and their* Lubrication *in the Glass Container Manufacturing Plant*

by D. E. Grube and A. B. Walker

Owens-Illinois, Toledo, Ohio

The glass container industry cannot be classed as heavy industry when considering size of equipment or bearing loads as used in some industries.

Above normal temperatures and long expected operating periods of bearings in the bottle forming departments do present problems peculiar to the glass industry.

This paper discusses the type of bearings, operating temperatures, loads, service life of bearings, the characteristics of lubricants to perform satisfactorily for extended periods of time, and how laboratory testing has helped define the desirable properties of lubricants.

Comments are confined to the bearings of the glass container forming machines, related equipment and their lubrication. The corrugated paper box fabricating equipment and raw materials handling equipment are standard equipment representative of other industries and are not discussed in this paper.

Presented at the 16th ASLE Annual Meeting in Philadelphia, Pa., April 1961

There are two general types of container forming machines used in the United States. The first is the suction type which draws by vacuum the glass from a large revolving and shallow pot into the molds mounted on a rotating frame. This is known as the Owens machine, named after its inventor, Michael Owens. The other is the gob type machine, where the glass flows out of a long trough and is cut off in gobs and drops into the mold. The first of the gob type machines were used to form containers with flat bottoms, straight sides, and almost flat shoulders, such as the familiar 4 oz. oil sample container. Today, this machine makes most types of glass containers.

SUCTION TYPE MACHINE OPERATION

The glass for the suction type machines flows from the glass melting and refining furnace into a large shallow revolving pot about 5 inches deep and 13 feet in diameter. This is where the glass is conditioned to the proper working temperature, and is in a position for the molds to dip into the glass and draw the glass up into the mold by the use of vacuum. The temperature of the pot varies from 1800 to 2600 F. The revolving pot has a housing over it except for a very small opening where the forming machine dips into the glass.

The weight of the revolving pot is 36,000 pounds and it is supported on twenty-four, eight inch long tapered roller bearings, set in a race approximately 6 ft. in diameter, immersed in oil in a housing below the pot of glass. The housing is made of cast iron, and a raceway is finished for the tapered roller bearings. There is considerable heat radiated to the bearings from the hot refractory material. Temperatures range from 160 to 275 F. This operating temperature is too high for lubricating oils to last three and one-half years to six years, the normal life of the furnace, but by changing oil every six to nine months, good lubrication is obtained and wear is at a minimum. One plant has extended the life of the oil to three or four years by circulating it through a cooler.

The lubricant is also used to lubricate the vertical drive shaft bearings, worm gear speed reducer, and a variable speed transmission which are also exposed to abnormally high temperatures.

The oils which have given the most satisfactory service in those units in which the oil is replaced regularly are some of the internal combustion engine oils, grades SAE 40 and 50, Supplement I or II or the Series III oils. These oils have excellent oxidation resistance, good anti-wear properties, and little tendency to form hard varnishes. The use of these oils has resulted in cleaner bearings, less wear and less increase in viscosity as compared to straight mineral oils having a viscosity of about 2500 SUS at 100 F. which were formerly used.

Lubricant performance specifications and laboratory tests are necessary to secure the proper oils at the lowest price, because one brand of oil listed as an Mil-L-2104A may perform as well as another brand listed as a Supplement I or II oil, or an oil listed as meeting the Series III specifications. Some oils that are not classified as an internal combustion engine oil have performed very well in the laboratory performance tests, and in our opinion, would give good service in this equipment. These are oils specially formulated for high temperature service, containing detergent-dispersants.

The main bearing of the suction type machine is a babbit bearing approximately 5¾ inches wide, having an inside radius of 39 inches. There is a force feed lubricator supplying the oil to the chamfered oil groove. Because of the large surface area of the bearing, the load is only about 30 pounds per square inch. The rotating cast iron face and babbit surface stay in good condition through several furnace campaigns, indicating hydrodynamic lubrication.

The king pin in each head of the suction type machine passes over the pot of molten glass. The pin and its bearings were the most difficult part of the machine to lubricate for many years. The maximum movement of parts is about 45° on the pin. The excessive heat soon carbonized the grease, and excessive wear occurred. Regular greasing of the bearing made things worse, and shortened life of assembly, hence, the only grease used was that in packing bearing at time of assembly. Later, a hole was drilled axially through the pin, and air blown through the center of the pin carrying away sufficient heat to keep bearing cool enough to give good service. An inexpensive machine oil is used for lubrication in place of grease.

Many motions of this machine are cam operated, and these cams have to be lubricated with an oil that will not oxidize or form hard deposits that will prevent roller from operating, because a stuck cam roller causes very costly damage to the machine, requiring about 12 hours to replace cam, roller and other broken parts.

There are many bearings besides the cams, which are lubricated either by force feed lubricators or are hand oiled. These and the bearings mentioned above are all lubricated by one oil.

Oils which have given good performance and are preferred most by the machine operators are low gravity straight mineral oils which have a viscosisty of about 300 SUS at 100 F. Naphthenic oils are preferred to the paraffinic because they have less tendency to form hard varnishes.

Rust inhibitors are desirable as the machines are stopped every few weeks for cleaning with steam hoses.

GOB TYPE CONTAINER FORMING MACHINE

The gob type container forming machine uses both bushings and antifriction type bearings, involving rotating and oscillating motions. The bearings are not heavily loaded and for the most part temperatures are not high enough to cause excessive trouble.

The most critical application and the one which governs the choice of the lubricant is the lubrication of air cylinders and valves.

There has been a lot of trouble with frozen piston rings, and erratic operation of pistons caused by moisture in the compressed air. After coolers are used, but do not eliminate all the moisture in the air. Many types of oils have been used and are being used today to lubricate these machines, and the price range is quite large.

Normally, the same oil used for air cylinder lubrication is used for bearing lubrication. One of the major items that has eliminated trouble on this container forming machine is the use of force feed lubricators, delivering the oil through small tubing to each bearing and the air operated cylinder. The force feed lubricator has given a big improvement in machine operation as compared to the air line lubricators.

LEHRS

The glass container leaves the forming machine at temperatures of 1000 F or more and is put into a lehr (annealing oven) to remove stresses and to be cooled down to room temperature. The lehr is about five feet wide and 90 to 125 feet long, and the containers set on a continuous woven wire mat. Just before the containers are put on the mat, the mat goes over a roller about 3 to 4 inches in diameter, which is supported by an anti-friction bearing at each end. These two bearings have given much trouble, because frequently the gas flame that heats the mat is turned on too strong, and heats the bearings to abnormally high temperatures, often resulting in bearing seizure. A lubricant has not been found that will stand up under these conditions for 3½ to 5 years at a time. Many greases and oils are satisfactory if the flame is properly controlled. Where space permits, the bearings are being moved farther from the flame. Wick oilers mounted away from heat with tubing conveying the oil to bearing seems to do better under these adverse conditions than grease, but frequently leave an oil spot on the floor, under the bearing, which has been objected to by the Good Housekeeping Committee.

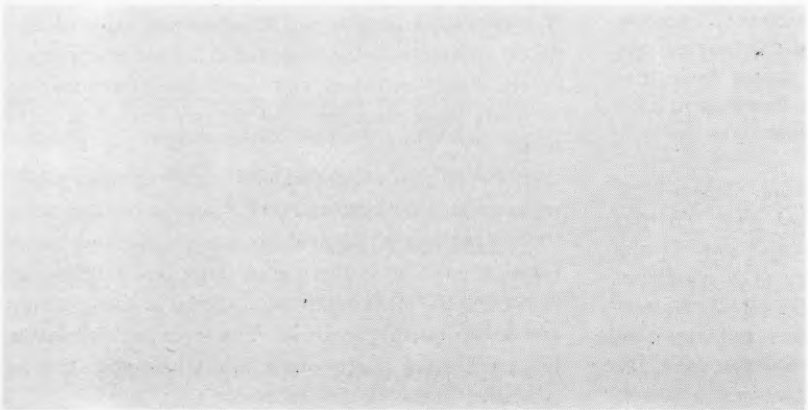
In the glass container forming plant, a lot of blowers and fans are used to provide wind for combustion, cooling of furnace refractories, mold equipment and the machine operators. The motors driving these fans range from 3 to 150 horsepower in size. The fans supplying cooling wind to the furnace refractories normally operate from three and one-half to six year periods, but seldom is any maintenance work done on this equipment during the holiday down periods. Grease lubricated anti-friction bearings are now used on the fans and motors. Grease is added at regular intervals. The use of sealed bearings that require no lubrication during operation have not been very well accepted by plant operating personnel for this equipment. Many greases have been used satisfactory for the lubrication of these bearings, such as lithium and sodium soap base greases. However, the sodium base in general is preferred by plant operators. Some of the new calcium complex type greases are being tried on these bearings and to date have been satisfactory. The latter grease, if successful in these bearings, may make it possible for a plant to use only one grease, as this grease is also suitable for use on the glass container forming and handling equipment, where a high temperature grease is often preferred.

The air compressors used to supply compressed air for the container forming machines are normally single stage, double acting type, discharge pressure 50 psig. and the motors range in size from 125 to 800 horsepower. A good quality oil with oxidation and foam inhibitors with a viscosity of 300 to 450 SUS at 100 F has given very good service for lubrication of these bearings.

SUMMARY

In summarizing the discussion, three items are brought out that may be considered necessary for good lubrication. These items are:

1. Changes in design of equipment to provide working conditions suitable for available lubricants.
2. Selection of proper lubricants.
3. Proper application of lubricant, such as the use of suitable oil and grease lubricators, and changing of lubricant at proper intervals to prevent excessive wear.



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Breakdown of EP GEAR LUBRICANTS *in Pinion Bearings*

Bearing wear and corrosion were investigated for seven multipurpose EP gear lubricants using a large off-highway truck axle in dynamometer tests. The wear tests were of 300 hours duration at a temperature of 250 F, while the corrosion tests were cycled between room temperature and 150 to 300 F. The degree of lubricant breakdown occurring in the axle tests was also observed in concurrent chemical and physical bench tests made on oil samples drawn from the axle housing at regular intervals.

Load carrying ability, oxidation stability, and corrosion properties were found to differ considerably for the currently available lubricants at operating temperatures above 200 F. Bearing wear was shown to be directly related to the presence of metallic particles resulting from gear damage.

These studies indicate that the present EP gear lubricants are temperature sensitive in the range of 200 F and above, and that unsatisfactory axle performance might be expected when the operating temperature of axles are above this value.

Presented at the 16th ASLE Annual Meeting in Philadelphia, Pa., April 1961

INTRODUCTION

The authors' laboratory has a continuous program for the evaluation of passenger car, industrial and truck axles. This work includes axle deflection tests using a modified Gleason deflection test machine or a 700 hp dynamometer, oil flow tests, and bearing wear tests on a 75 hp dynamometer or the 700 hp dynamometer. The bearing wear tests, which are normally run at 100 to 150 per cent of rated engine torque, include gear and lubricant performance. Some tests originate from field problems while others are tests on new designs.

This paper presents the results of a bearing wear investigation on a new model forward axle in a tandem drive, for a six wheel, off-highway truck, tested in the 700 hp dynamometer. The early tests indicated a wide divergence in performance characteristics for the currently available multipurpose EP gear lubricants. Specifically, the lubricant properties of load carrying ability, oxidation stability, and corrosion were of particular interest.

The background of EP gear lubricant development beginning with the introduction of the hypoid gear in the period of 1927 to 1930 and up to the present time has been summarized in a report by Hunstad, et al. (1) and in the CRC reports (2, 3, 4). Also, a recent

article by Noll (5) helps to clarify the present terminology for gear lubricants in explaining the API Service GL-4 designation. A common goal has prevailed throughout the years to provide for a balanced chemical activity sufficient to prevent excessive gear wear without causing detrimental effects upon bearings and other components in the axle. Over the years, the higher speed and higher horsepower of modern vehicles has made increased demands upon the lubricant. It is of interest to note that corrosion was one of the early problems associated with gear lubricants. The CRC report (2) on moisture corrosion mentions corrosion as the greatest contributing factor to extremely early gear and bearing failures with the first hypoid lubricants. One of the bench tests developed during this period to measure wear resulting from the lubricant chemical activity was the Timken Lubricant Tester (6, 7, 8, 9, 10). The test also provided a relative index of extreme pressure film strength for the lubricant. The present military specification (11) for multipurpose gear lubricants, MIL-L-2105A (ORD), recognizes and includes acceptable limits for both moisture corrosion and additive activity level. A major factor affecting corrosion is the temperature sensitivity of the lubricant. Bulk oil temperatures up to 300 F are possible in the CRC L-37 and L-42 dynamometer tests, but the length of time at these higher temperatures is less than 24 hours. Certain lubricants will pass the short term tests but will develop corrosion after prolonged operations above 200 F.

An active program is being pursued in the authors' laboratory to record bulk oil axle temperatures for passenger and truck vehicles. Temperatures are being recorded for new truck axles during the delivery trip from the factory to our Canton plant. Also, new axles have been installed in passenger cars for temperature measurements. Maximum bulk oil temperatures of 220 F have been recorded during the first five hours running of new axles in passenger cars. The temperature has dropped to below 200 F after the initial break-in period. Oil temperatures in broken-in truck axles which have larger oil capacities (over 8 pints) as compared to passenger car axles (2 to 4 pints) have not exceeded 200 F. It appears that the present operating oil temperatures in axles are below the threshold temperature where more severe corrosion might develop.

The main purpose of this paper is to emphasize that present EP gear lubricants are temperature sensitive in the range of 200 F and above, and that satisfactory bearing operation in this temperature range could be limited by the breakdown characteristics of available lubricants.

TEST PROCEDURES

The rear axle used in these tests is the forward axle in a tandem drive from a large off-highway truck. The carrier is a single reduction type, 3.9 to 1 ratio, hypoid assembly with a straddle mounted pinion and a 21⅛ in. diameter ring gear. The pinion has a right-hand spiral and is top mounted. Tooth bearing on drive is on the concave side of the gear teeth. An additional reduction of 4.7 to 1 is obtained with a planetary gear set at the wheels. Fig. 1 shows a photograph of the axle mounted on the 700 hp dynamometer.

The dynamometer has a two-speed (1750 and 3500 rpm) 2300 volt AC drive motor coupled to an eddy current clutch. This arrangement allows speed control from approximately stall to 3500 rpm with a maximum torque of 1050 lb-ft throughout this range. Input torque to the test is measured by means of a strain gage equipped torque pickup shaft indicated at the test control console. The output torque is absorbed in two eddy current brakes. These brakes have a total capacity of 30,000 lb-ft torque at speeds of 50 to 1000 rpm.

The test procedures consisted of three parts, although all of the lubricants tested were not run for each of these procedures. These tests were (a) a bearing wear test, (b) a cyclic corrosion test, and (c) a laboratory corrosion test on oil samples removed during the cyclic corrosion test. The various gear lubricants tested, together with the type of tests performed, are summarized in Table 1.

The bearing wear tests were set up with the following conditions of operation:

Test duration	300 hr
Oil temperature	250 F
Pinion speed	1650 rpm
Approximate truck speed	16 mph
Input torque	1000 lb-ft

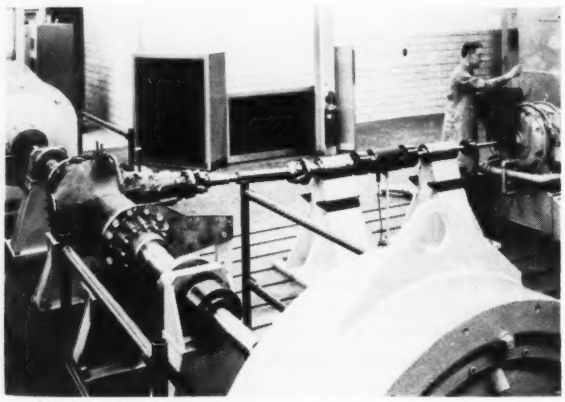


Fig. 1. Test axle on dynamometer.

TABLE 1.—IDENTIFICATION OF LUBRICANTS

LUBRICANT NO.*	ADDITIVE TYPE	SPECIFICATION OR SERVICE DESIGNATION	TYPE OF TEST
1	SCP	GL-4	Bearing wear
2	SCP	MIL-L-2105	Bearing wear
3	SCL	MIL-L-2105	Bearing wear
4	SCP Additive B	GL-4	Bearing wear
5	SCP Additive C	GL-4	Corrosion
6	SCP Additive D	GL-4	Corrosion
7	Modified SCP	GL-4	Corrosion

*All SAE 90 Viscosity.

In all starts, the torque was applied gradually beginning at 25% load for one hour, 50% load for one hour, and 75% load for one hour, before applying full load. In later starts, following stops for inspection and oil samples, full load was applied over a period of 15 to 20 minutes of operation. Temperatures were taken with thermocouples located one inch above the bottom in the main oil reservoir, in the bottom of the power divider reservoir, and in the pinion oil inlet channel. Elevated temperatures were maintained by the use of a fiber-glass blanket and heat lamps. External cooling was provided by two 16-inch forced air fans as required to maintain the desired oil temperature. The normal oil level required 20 quarts in the main reservoir plus one quart in the power divider reservoir. One-half pint oil samples were taken and not replaced at four to five inspection periods during the tests.

The corrosion test procedure consisted of four to five cycles of eight hours running followed by a twelve-hour idle period during which the axle was allowed to cool to below 100 F without fans. These tests were run with oil temperatures of 150, 200, 225, 250, and 300 F. Three bearing cups which were washed in kerosene and wiped dry were suspended inside the axle during the twelve-hour idle period as follows:

1. Submerged in the oil
2. Dipped in the oil, then suspended one inch above the oil
3. Dry (not dipped) suspended one inch above the oil

The corrosion test cups were suspended from an arbor bar fixture installed in the bore of the tubular pinion after each run. The assembly was closed up, except for the breather pipe, during the twelve-hour idle period. The cups were stored in the open in the dynamometer room under conditions of 75 to 80 F and 40% RH after the twelve-hour exposure in the axle. Figs. 2 and 3 are sketches of the axle center showing the location of the thermocouples and corrosion test cups.

Oil samples removed after each eight-hour running period in the cyclic corrosion test were further evaluated in a modified CRC static corrosion test for 7 days at 80 F and 95/100% RH. This test followed the standard CRC procedure (12) except for oil being used instead of grease and omitting the bearing run-in step and the water immersion step. Essentially, this test was the equivalent of a humidity cabinet test on bearings dipped in used gear oil.

Throughout all of the above tests, each oil sample was analyzed for complete physical properties. Both the new and final used oil samples were evaluated for Timken load carrying capacity.

RESULTS OF BEARING WEAR TESTS

Lubricant No. 1 failed after 16¼ hours running at 250 F. A strong offensive odor was noticed after 3½ hours operation. The first stop for inspection at 16¼ hours showed a gummy deposit on the edges of the gear teeth. As the axle cooled, the torque required to turn the assembly increased rapidly until the pinion would not turn under a 500 lb-ft load. The teardown inspection revealed an excessive amount of a black, carbonaceous, resinous deposit in all bearings, on the gears, and in various oil pockets on the carrier. The photograph in Fig. 4 shows the deposit on the forward pinion bearing. The gears showed heavy pressure areas of contact but no scuffing was apparent.

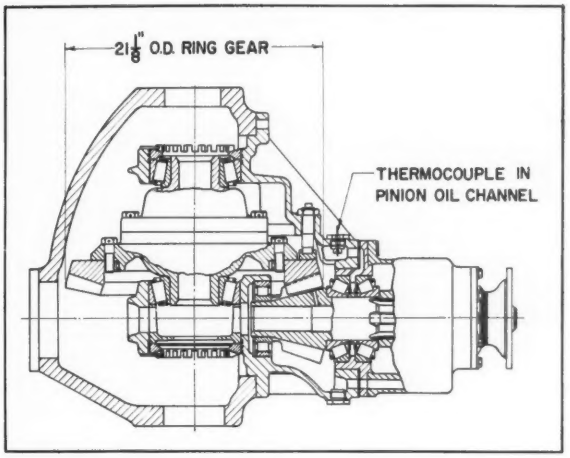


Fig. 2. Plan view of test axle.

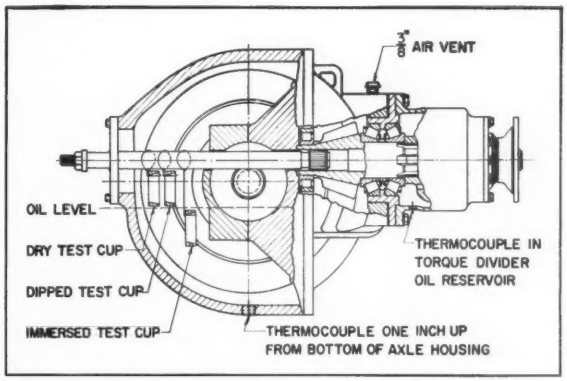
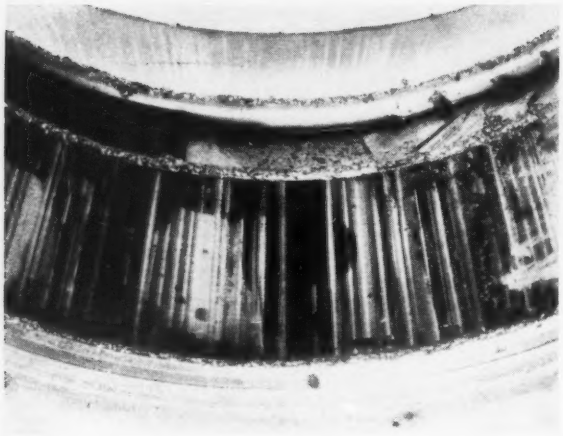

⅜" AIR VENT
OIL LEVEL
DRY TEST CUP
DIPPED TEST CUP
IMMERSED TEST CUP
THERMOCOUPLE IN TORQUE DIVIDER OIL RESERVOIR
THERMOCOUPLE ONE INCH UP FROM BOTTOM OF AXLE HOUSING

Fig. 3. Side view of test axle.

The entire unit was cleaned so that the same set of gears, but with new bearings, could be used in the bearing wear test for Lubricant No. 2. Gear scoring and wear developed in the second test between the inspections of 137½ and 201 hours. Considerable metal was present in the lubricant and all bearings showed excessive wear after 201 hours operation at 250 F. The used lubricant analysis showed 0.55% iron present. Fig. 5 is a photograph of the scored pinion and ring gear.

A new gear set along with new bearings was installed in the axle for the bearing wear test with Lubricant No. 3. The unit completed the desired run of 300 hours at 250 F in satisfactory condition. The bearings retained their adjustments indicating an insignificant amount of wear for both the gears and bearings. The condition of these gears after test is shown in Fig. 6.



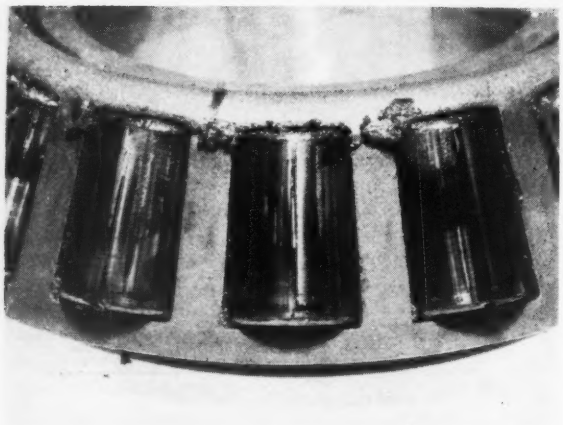
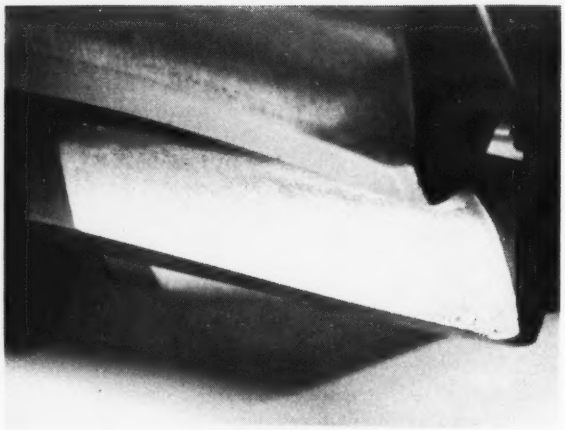
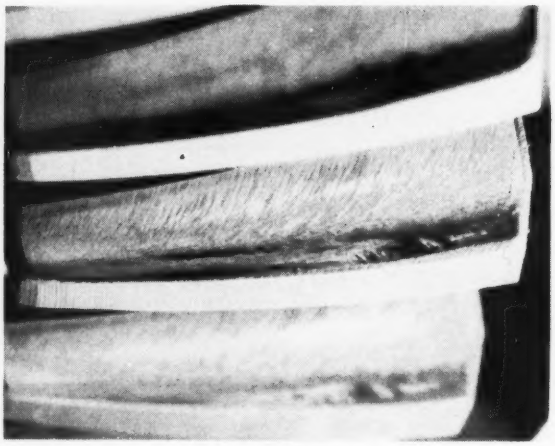


Fig. 4. Deposit on pinion bearing after 16-¼-hr run at 250 F with Lubricant No. 1.

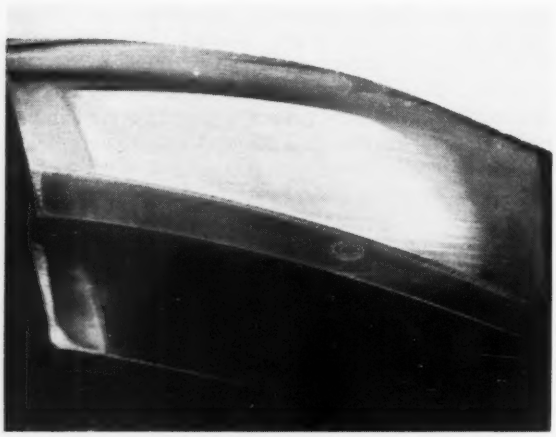


PINION GEAR

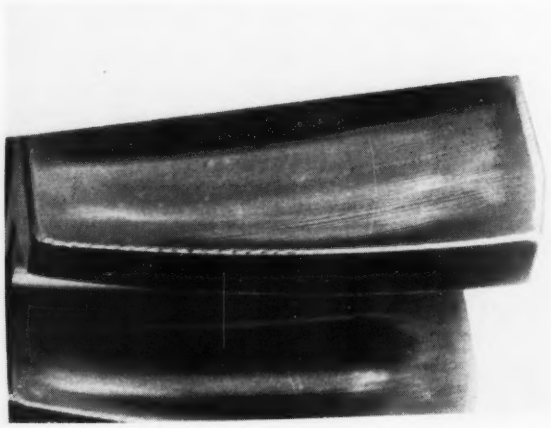


RING GEAR

Fig. 5. Gear set scored after 201-hr run at 250 F with Lubricant No. 2. (Same gear set used with Lubricant No. 1).



PINION GEAR



RING GEAR

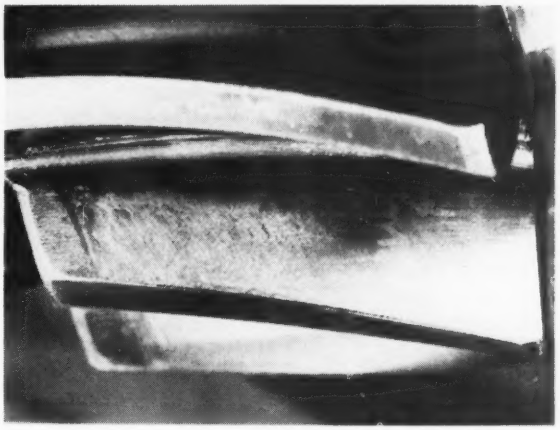
Fig. 6. Gear set satisfactory after 300-hr run at 250 F with Lubricant No. 3.

The final bearing wear test was run with Lubricant No. 4 using the same bearings and gears which were in satisfactory condition from the previous tests. In all cases, new lubricant was used for each test with the axle being thoroughly cleaned with kerosene followed by a flushing with the new lubricant before final filling. Lubricant No. 4 also completed the 300-hour run at 250 F free of excess wear on the bearings or gears. The condition of the ring gear and pinion is shown in Fig. 7. The greater contrast noted in Fig. 7 resulted from the discoloration of the gear teeth by the corrosive nature of the lubricant. This photograph might erroneously be interpreted as gear damage, but neither the gears nor bearings showed excessive wear. In both Tests 3 and 4 where excessive gear and bearing wear did not occur, the amount of iron in the used lubricant was at a low level (0.1% iron or less).

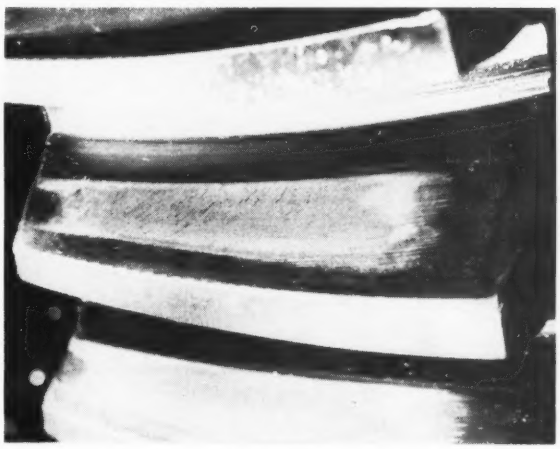
Evidence of lubricant oxidation products was present after Tests 3 and 4 in the form of deposits in the axle. In addition, corrosion was found after Test 4 on the bearings, inside of the housing, and on the axle shafts. The amount of corrosion on the bearings is shown in Fig. 8. Table 2 is a summary of bearing wear test results.

TABLE 2.—Summary of Bearing Wear Test Results

LUBRICANT NO.	SPECIFICATION OR SERVICE DESIGNATION	TEST DURATION (HR. @ 250 F.)	RESULTS
1	GL-4	16¼	Test stopped; excessive black deposit.
2	MIL-L-2105	201	Gears scored; bearing wear
3	MIL-L-2105	300	Gears OK; no wear
4	GL-4	300	Gears OK; no wear; corrosion on bearings, housing, and axle shafts

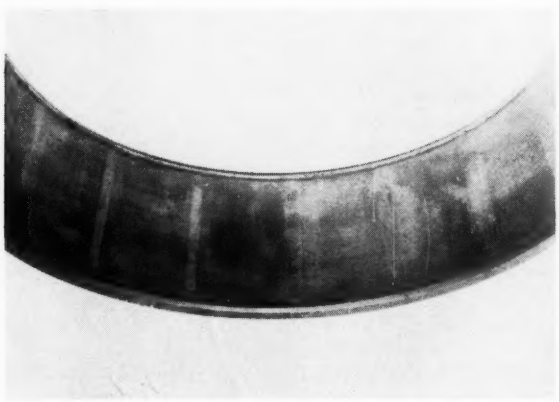


PINION GEAR



RING GEAR

Fig. 7. Gear set satisfactory after 300-hr run at 250 F with Lubricant No. 4. (Same gear set used with Lubricant No. 3).



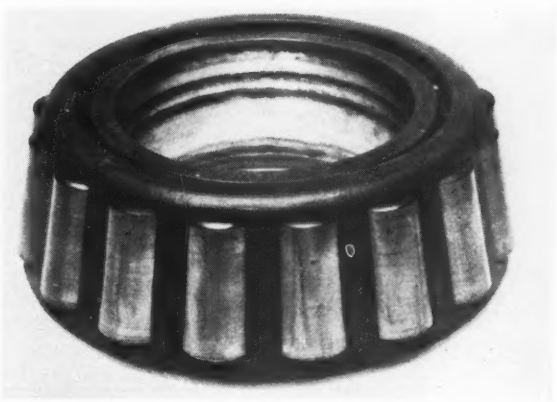


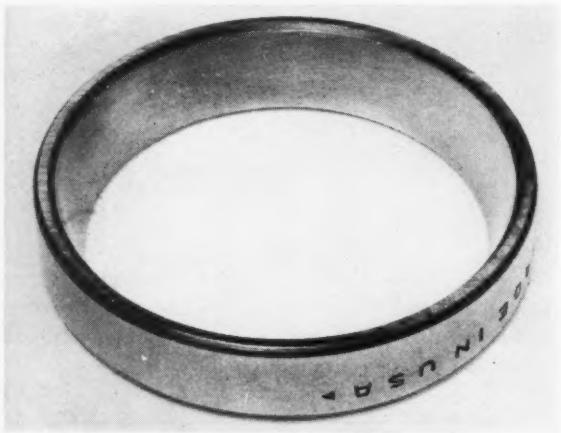
Fig. 8. Corrosion on differential bearing after 300-hr run at 250 F with Lubricant No. 4.

RESULTS OF CORROSION TESTS

The bearing wear test with Lubricant No. 4 indicated appreciable chemical change in the lubricant with the formation of strong acid decomposition products. It was possible to produce corrosion on clean bearing races exposed to the hot oil vapors for seven minutes followed by one-hour storage in the dynamometer room, Fig. 9.

These findings prompted the corrosion study for gear lubricants which are summarized in Table 3. Lubricant Nos. 4, 5, and 6 were essentially the same type base stocks each with a different EP additive. Lubricant No. 7 contained a new modified sulfur-chlorine-phosporous type additive which did not produce corrosion in the axle tests.

The corrosion produced in the modified CRC test on used oil samples from the axle test is presented in Figs. 10, 11, and 12. The CRC static corrosion test was slightly more severe than the axle test which might be attributed to a longer storage at a higher relative humidity.



NOT EXPOSED TO VAPOR

EXPOSED TO VAPOR

Fig. 9. Corrosion on dry test cup placed in hot axle for 7 minutes after 200-hr run at 250 F with Lubricant No. 4.

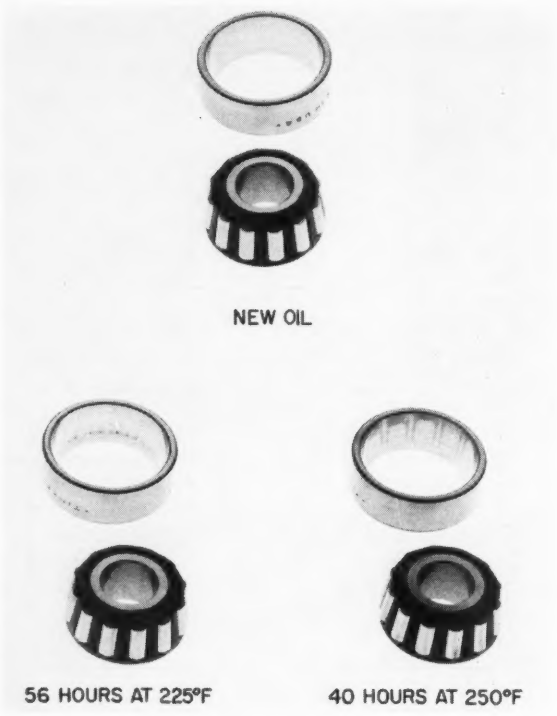


Fig. 10. Static corrosion test bearings using axle test Lubricant No. 5.

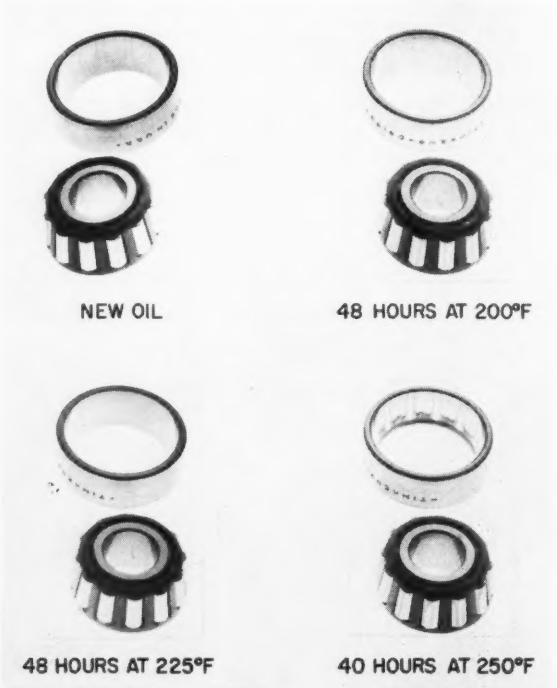


Fig. 11. Static corrosion test bearings using axle test Lubricant No. 6.

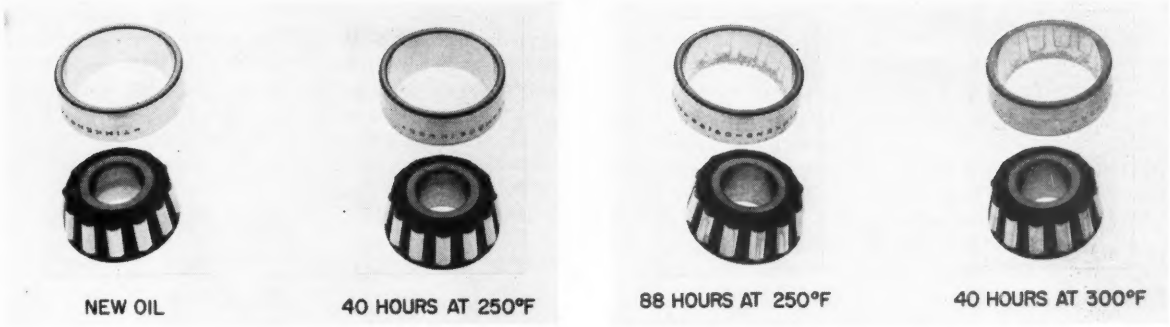


Fig. 12. Static corrosion test bearings using axle test Lubricant No. 7.

TABLE 3.—Summary of Corrosion Test Results

LUBRICANT NO.	SPECIFICATION OR SERVICE DESIGNATION	THRESHOLD TEMPERATURE FOR CORROSION	
		CUPS EXPOSED IN AXLE	MODIFIED CRC TEST*
5	GL-4 Additive C	Dry —24 hr, 250 F Dipped —24 hr, 250 F Immersed—No corrosion after 40 hr, 250 F	40 hr, 225 F 8 hr, 250 F
6	GL-4 Additive D	Dry —32 hr, 225 F Dipped —No corrosion after 40 hr, 250 F Immersed—Same	24 hr, 200 F 8 hr, 225 F 8 hr, 250 F
7	GL-4	Dry —No corrosion after 63 hr, 300 F Dipped —Same Immersed—Same	3 corrosion spots 40 hr, 250 F Light stain 8 hr, 300 F

*Used oil samples from axle cyclic corrosion test.

DISCUSSION OF RESULTS

The effect of temperature upon the chemical activity of the additives in EP gear lubricants can be shown by comparison of new and used lubricant properties as indicated in the Timken test, and change in pH value, and the corrosion characteristics. The change in Timken load before and after the dynamometer tests is summarized in Fig. 13. Prolonged exposure at high temperatures has resulted in an increase in Timken load for the GL-4 type lubricants whereas a decrease in load was noted for the MIL-L-2105 type lubricants. This relationship between load carrying ability and chemical activity is present in different degrees in the various bench tests used for the evaluation of new EP gear lubricants, notably the Timken, Falex, and Four-Ball tests. The bench test load-carrying values for new lubricants appear to be influenced by the volume of the lubricant sample required for each test. The Timken test uses a three-quart lubricant sample whereas both the Falex and Four-Ball tests use a 100 ml. sample. Higher load-carrying values may be obtained for new lubricants in the Falex and Four-Ball tests when compared to the Timken test with certain temperature sensitive GL-4 type lubricants. An analysis of the data in a recent paper presented by De Ardo and Sargent (13) suggests such a relationship might exist.

The pH of the used oil was measured electrometrically with a calomel-glass electrode system. A decrease in pH, corresponding to the formation of acid materials, was noted as corrosion developed in the test axle. These data are shown by the charts in Figs. 14, 15, and 16. It follows that the presence of strong acid type materials, which are defined as occurring below a pH value of 4.5, also are related to the corrosion properties. The dry test cup was most sensitive to a corrosive condition present in the lubricant. The occurrence of corrosion on the dry cup, during the twelve-hour period in the axle, is indicated by the letter "C" along the curves in Figs. 14 and 15. The dry cup did not corrode with Lubricant No. 7, Fig. 16, where only a small change in pH resulted.

The change in viscosity is of practical interest as an indication of lubricant stability. Table 4 shows the change in viscosity measured at 210 F versus time in the dynamometer tests run at 250 F. The viscosity change was related to the presence of deposits in the axle for Lubricant Nos. 3 and 4, but this was not true for Lubricant No. 1.

The bearing wear tests are significant in that satisfactory performance of the axle is dependent upon each component part in the unit including the lubricant. Bearing wear is prevented with satisfactory gears in combination with an adequate lubricant. In addition

to bearing wear being caused by metallic particles from gear damage or poor gear contact, another equally important factor is contamination of the axle by dirt from environmental conditions. Such a condition is most frequently encountered in industrial truck axles where appreciable amounts of cement and silicious materials have been found in used oil drain samples. Laboratory tests have been run previously in axles where the lubricant was supplied separate from the axle housing to eliminate the effects of contaminants and metallic particles generated by poor gear contact. Such tests have always shown that excessive bearing wear does not take place in the absence of abrasive wear particles. The beneficial effects of regular drain periods together with the use of magnetic drain plugs has been demonstrated by others (14) in heavy duty axles where service well beyond 200,000 miles was achieved without loss of bearing adjustment.

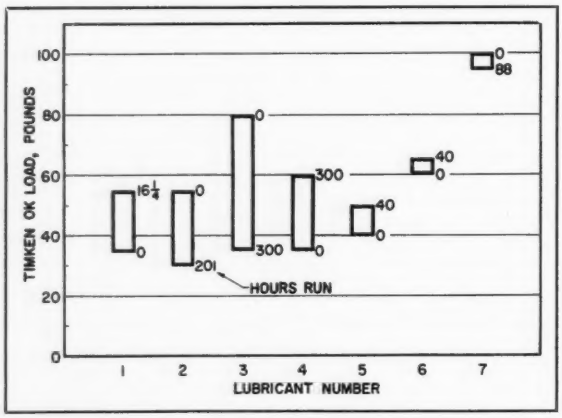


Fig. 13. Change in load carrying capacity after dynamometer tests at 250 F.

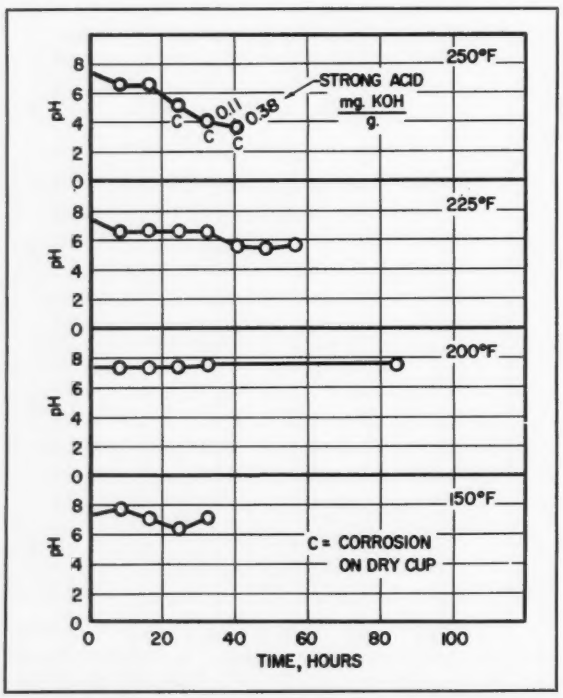


Fig. 14. Occurrence of corrosion in cyclic test versus pH and strong acid for Lubricant No. 5.

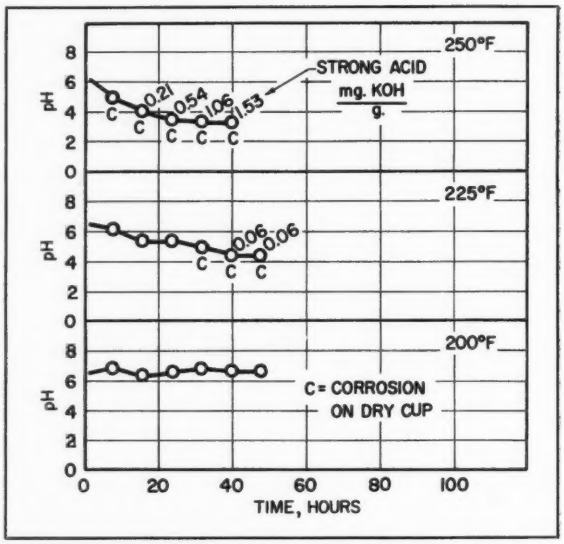


Fig. 15. Occurrence of corrosion in cyclic test versus pH and strong acid for Lubricant No. 6.

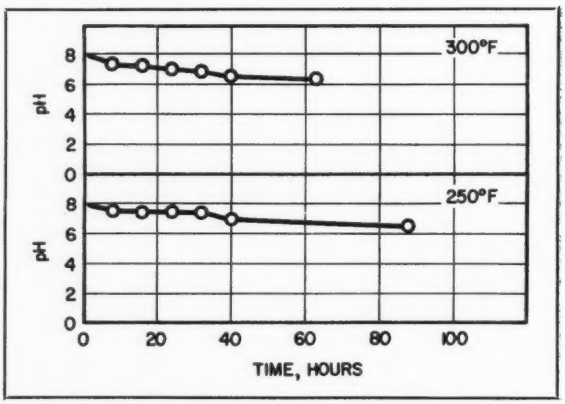


Fig. 16. Cyclic test for Lubricant No. 7 versus pH where corrosion and strong acid did not occur.

TABLE 4.—Effect of Operating Time at 250 F Upon Viscosity, SUS @ 210 F

TIME HOURS	LUBRICANT NO. 1	2	3	4	5	6	7
0	83.0	87.3	94.5	89.2	89.7	89.1	90.2
16	84.4	—	—	—	88.4	89.2	87.8
25	—	—	87.0	89.4	87.9	88.9	87.9
40	—	—	—	—	87.5	89.4	88.4
45	—	89.1	89.0	—	—	—	—
90	—	—	96.5	—	—	—	89.0
200	—	99.7	103.6	92.9	—	—	—
300	—	—	117.5	98.4	—	—	—

CONCLUSIONS

The dynamometer axle tests resulted in different degrees of chemical change for the seven EP gear lubricants used. These changes were substantiated by the tests for lubricant physical properties, Timken load-carrying capacity, and corrosion.

The successful operation of pinion bearings in vehicle axles operating at temperatures above 200 F is largely dependent upon the stability of the gear lubricant.

Contamination of the lubricant with abrasive particles worn from the gears causes excessive bearing wear and loss of adjustment. The occurrence of deposits and corrosion from lubricant breakdown also can cause unsatisfactory bearing performance.

It is believed that unsatisfactory axle performance might be expected with some currently available gear lubricants if the operating temperatures of axles were to exceed 200 F for prolonged periods through reduced lubricant volume, higher loading, higher speed or a combination of these factors.

ACKNOWLEDGEMENT

The authors wish to express appreciation to members of the Physical Laboratory for their assistance in performing the test work and in preparing the manuscript. The authors also wish to express their gratitude to their associates for their valuable guidance and comments, namely, H. R. Neifert, Chief Engineer, Physical Laboratories; H. T. Peeples, Lubrication Engineer: R. L. Williams, Chief Engineer, Automotive Engineering; and E. Anderson, Service Manager.

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DISCUSSION

by I. G. Detra, Executive Engineer, Gear Design Department, Mack Trucks, Inc., New York, New York

As you may have already gathered, we were closely associated with the series of tests reported here. As a result, we are basically in agreement with all the facts presented. However, it is apparent that several points will be benefited by further discussion. I will attempt to review these points in the order in which they occur in the original paper presented so ably by Messrs. Ellis, Hill, and Downs. As the various considerations are discussed, you may note that two basic underlying factors influence our analysis.

1. Is there really a sharp line of demarkation near 200 F. below which most EP lubricants function to an acceptable degree?
2. How does data such as is presented here apply to actual service performance?

Two types of tests (bearing wear and corrosion) are mentioned in the abstract. Actually, the corrosion tests were outgrowths of the wear tests decided upon because of poor lubricant performance during the first test conducted under accelerated conditions. The fact that the corrosion tests were established before we were fully certain such corrosion would actually occur in service makes them somewhat of an oddity in the annals of physical testing. Such foresight is to be commended, however, in view of the fact that even the possibilities of corrosion or coking is distressing to those of us who must use EP lubricants.

The abstract also states that "Load carrying ability, oxidation stability, and corrosion properties were found to differ considerably for the currently available lubricants at operating temperatures above 200 F." Frankly, I believe this is true at almost any temperature. In efforts to establish a suitable lubricant specification, the writer's company has analyzed dozens of gear oil brands by means of all standard mechanical and chemical bench tests. If the brands which deviate much from average for each test parameter are eliminated from the acceptable list, very few lubricants remain to be recommended for use. Apparently, we

must be very tolerant of lubricant characteristics from this point of view. As far as mechanical tests, such as Timken Load, Four-Ball, & Falex are concerned, we are on the fence in considering their value. Each measures performance at conditions different from actual service. Our own power divider, for instance, has rather special lubrication requirements; and, we know a few brands which far out-perform the average, but we don't know why, nor are we certain that these same brands are best for gear performance. It is obvious that much basic knowledge remains to be learned in the field of lubricant analysis and evaluation.

Finally, the abstract states that "present EP lubricants are temperature sensitive in the range of 200 F and above." This certainly was true for the conditions of the test reported. But, the fact remains that we occasionally encounter indications of corrosion in actual carrier service which usually operate below 165 F and seldom get over 180 F. Just recently, for instance, we have experienced several cases of corrosion involving a large oil company, and had them send us several used oil samples. When analyzed by means of the Timken corrosion bench test, the samples which had not traveled over 6,000 miles checked out fine. As mileage increased beyond this point, corrosive effects also increased. This is an illustration of why we believe that time is a powerful factor to be considered in actual service regardless of bulk oil temperature. Perhaps some error lies in the use of bulk temperature as a basic parameter effecting breakdown. After all, where does most of the breakdown occur—in the bulk reservoir or at the tooth contact faces? Personally, I do not know, but we all know that breakdown and reaction with gear steel must occur at the tooth faces if EP additives are to accomplish their purpose. It would be most interesting to measure instantaneous temperatures at gear tooth contact surfaces.

Under the heading *Test Procedure*, there is one factor worthy of some clarification. The 1,000 lb ft torque used for this series of tests is not considered a very high load for the test carrier. Whether this had any effect on test results is pure conjecture. However, I am certain that tooth surface temperatures reach higher values under service conditions than experienced here.

The 16¼ hour lubricant failure described in the paper under *Results of Bearing Wear Tests* has sidelights which are of interest. We now know that this particular oil resulted from a supplier's over-eagerness to compound a MIL-L-2105B lubricant. According to his reasonably plausible admission, too much standard additive was used. This experience illustrates the potency and sensitivity of modern gear lubricant additives. I might add that we have also had other experiences in which an oil supplier admitted to the use of additives which were not 100% controllable. This again illustrates the responsibilities facing oil companies in compounding lubricants which will get optimum performance out of geared units.

Now we must face the question of what can be done with the type of information presented here. Frankly, I must be honest in admitting that we cannot point to any series of failures definitely resulting from corrosion. We have had suspicions, but no proof. Perhaps we have been unduly worried, but the potential of lubricant corrosion is terrifying to manufacturers of geared components. Therefore, we must remain vigilant. More tests of the type reported here must be conducted, and we must learn how to apply this knowledge to actual service conditions. It is axiomatic, of course, that we avoid, in service, the conditions of our accelerated tests.

In summing up, I will state that what we need most in connection with gear oil is a simple specification or other means for defining or selecting a suitable product. Obtaining this will require the fullest cooperation from all interested parties.

DISCUSSION

by Val Gates,
Shell Oil Company

I appreciate the opportunity given to me to discuss the excellent paper and interesting data presented by the authors. These data, relating to high temperature EP gear oil performance, are of importance to both the petroleum and equipment manufacturing industries, and there is little doubt that higher gear box temperatures will be with us in the future.

For a number of years little development of any major significance occurred regarding new automotive EP gear lubricant additives. Performance was tied essentially to the requirements of specification MIL-L-2105. Certain oxidation stability problems arose which sparked the development of a new military specification MIL-L-002105A(ORD), and we saw the emergence of the GL-4 definition for gear lubricants. These resulted in a marked increase in activity regarding EP additive development. New and more severe performance levels were set by the new MIL specification, and new means for measuring these levels were adopted. New levels of EP activity, and new means for assessing thermal or oxidation stability evolved.

Based upon a variety of laboratory tests, and broad field results, we would conclude that most of the widely used additives today do a good job of providing EP protection to gear surfaces, if used within proper load limits. We find too that this EP protection is provided over a reasonable temperature range.

In the field we note that lack of stability of a gear lubricant is more of a problem than lack of load carrying ability. Products of instability have their deleterious effects, and more serious relating to corrosion. The authors have demonstrated temperature sensitivity of several EP additives, and illustrate that for the most part today's popular additives become corrosion sensitive near 225 F. They likewise have shown that this sensitivity can be extended to near 300 F.

At this point it may be well to emphasize a need to more fully describe the "corrosivity" of an EP gear lubricant. Staining of gear and bearing surfaces is considered by some to be corrosion. This may be merely part of EP activity designed into the additive.

There may be an obvious chemical attack upon bearing, gear and other metal surfaces, resulting from an uncontrolled formation of corrosive compounds during use and thermal decomposition of an EP additive. This may be called rust. Still another form of corrosion might be evident as a loss of anti-rust protection in the presence of moisture, also being seen as a form of rust. Rusting in the latter two instances are by differing mechanisms, hence a more accurate description is desirable.

Perhaps the term "corrosion" should be further described as "stain," "chemical," or "water-rust," etc.

At this same time we wish to point out that the seriousness of corrosion may be very dependent upon the time element, and whether a gear box is in a static or dynamic condition. Deleterious corrosion occurring during static conditions may not become evident until long after equipment is put into operation. Also the absence of obvious corrosion during dynamic conditions is no assurance that a lubricant will be corrosion-free under other conditions of service or storage.

The authors have done well with their investigation of EP activity and stability for a variety of compounds. We believe that a study of the anti-rust properties of the many samples available to the authors would be a valuable addition to the data already presented, and would provide a more complete performance picture of the additives considered.

It is my personal opinion that in general throughout our industries the significances of used EP gear oil properties, and their relationship to bearing and gear life are not given enough study. Much more can be learned from used oil properties, which may have an important bearing toward increased gear box life. We must not overlook the fact that many gear boxes are lubricated and protected by used gear lubricants for most of their service life.

We are faced with a rather limited knowledge of actual gear box temperatures in the field. In this I include all types of boxes under a wide range of operating conditions. We are glad the authors are doing work along this line, as more information of this sort is needed for a better definition of our temperature target. We would also like to know what gear surface and bearing temperatures our lubricants are exposed to in the field.

The authors operated a gear box in their laboratory at 300 F as a part of their investigation into thermal stability of lubricants. This temperature is probably considered beyond the normal experience in the field, but no doubt 300 F is reached from time to time. We ask of the gear, bearing and component people whether or not there are immediate or long range advantages to operations at these temperatures. Would the possibility of high temperatures allow for more flexibility in component and vehicle design? We say that today the use of more stable lubricants would permit operators to realize longer gear oil life, as an immediate advantage.

On the other hand, we may encounter a problem of potential seriousness stemming from high temperature operation, namely, gear surface tempering. If a gear box is operated to produce nominally a 300 F bunk oil temperature, gear surface temperatures could exceed tempering temperatures. This has been confirmed in a few instances, and could be a serious limitation on the useful life of a gear. This might well be a matter for metallurgists to study.

The temperature range well above 200 F will not be overlooked by any of us in those industries involved. We appreciate the fact that the authors have brought to our attention an area in which deficiencies appear, and no doubt we individually will seek our own best solutions.

AUTHOR'S CLOSURE

We appreciate the discussions of our paper prepared by Mr. I. G. Detra and Mr. Val Gates. Mr. Detra's first question asked if 200 F was really a critical temperature. In our test findings, operating time as well as temperature is indicated to be an important factor in the ability of a lubricant to function to an acceptable degree. To determine a more positive relationship between each of these factors would require extensive testing far beyond that which we made in our laboratory. From the data of our tests, we would not attempt to set up a critical temperature for lubricant operation in an axle. However, we do believe that with operating oil temperatures of 200 F and above, chemical changes in the lubricant detrimental to axle operation are accelerated to such a degree that serious trouble may be experienced with many of our present day lubricants.

The second question asked how this data relates to actual service performance. The data becomes directly applicable in the analysis of used oil samples from service applications. We have found strong acid products, loss of load carrying capacity, and marked changes in viscosity for samples of used gear oils returned from the field. These data give us added confidence in our appraisal of conditions inside the axle which enables changes to be made to avoid failure of the axle. Considerably more caution would be in order before using these data to predict service performance of new lubricants.

Mr. Gates mentions the need for a more accurate description of corrosion. We do believe that staining, tarnishing, and rusting are all correctly termed corrosion. A more complete description would require identification of the corrosion reaction products. Light stain or tarnish represent the early stages of corrosion and are not significant unless pitting is present. Unfortunately staining and tarnishing do not proceed very far before pitting becomes significant. We have found pitting on pinion bearings to a depth of 160 microinches after three months service.

For continuous operation at temperatures of 300 F or higher, we agree that the metallurgical characteristics of the gears and bearings should be considered.

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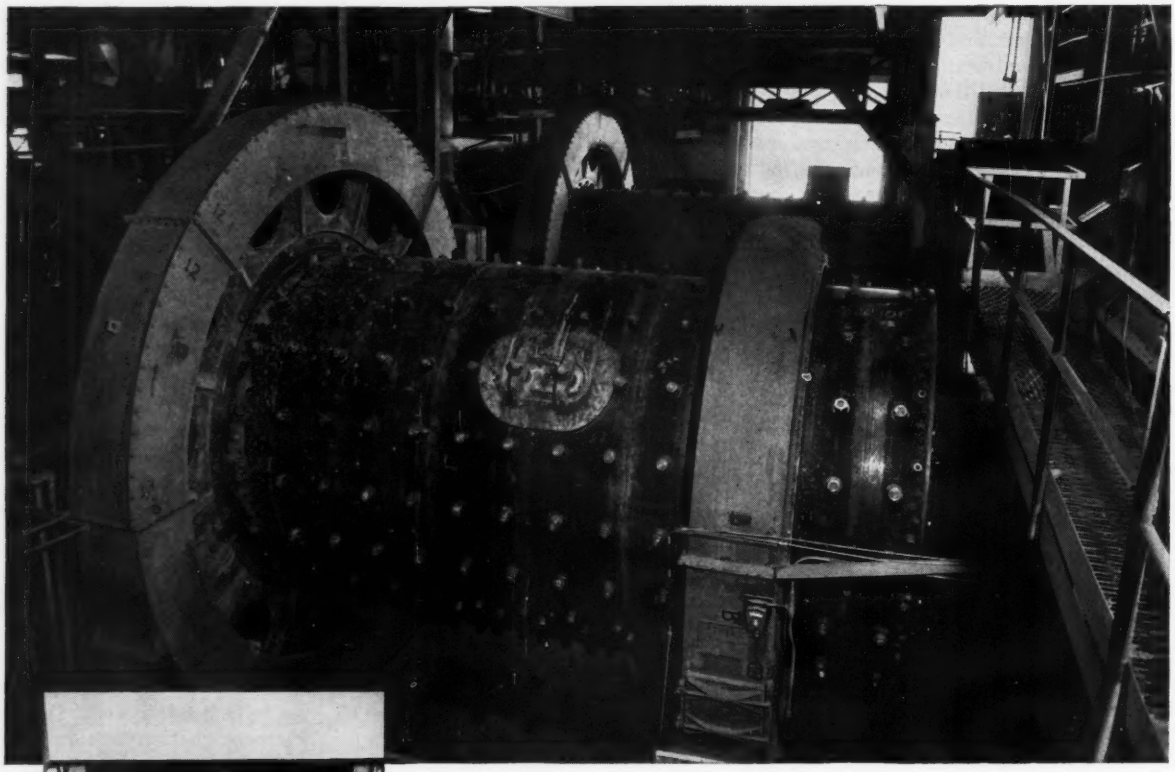

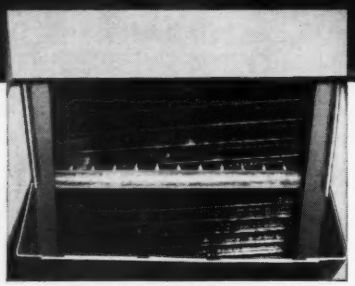

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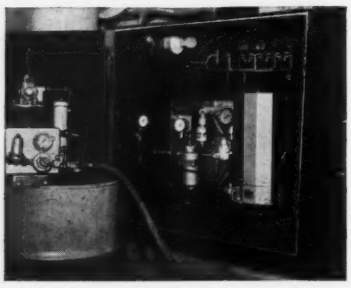

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Lubrication Abstracts

Edited by W. E. Campbell

Selected literature compiled by members of the Technical Committees and Industry Councils of the Society.

William J. Anderson and Edmond E. Bisson (Lewis Research Center, NASA, Cleveland, Ohio), "NASA Research On The High Temperature Bearing Problem," SAE Paper n1760, Apr. 5-8, 1960, 18 pp.

It is stated that solutions to problems in rolling-contact bearings are needed in three fields: lubrication, materials and fatigue. Approaches discussed are: development of high temperature lubricants, bearing materials, and nonconventional lubrication techniques. In rolling-contact bearings at elevated temperatures liquid, vapor, and solid phase lubricants have been tried. Other solutions for the extreme temperature problems have been sought in gases containing reactive atoms as lubricants and in dry operation. Fatigue studies of high quality tool steels and crystalline ceramics have been initiated. Preliminary studies have been performed on journal bearings with liquid-metal lubrication and with gas lubrication. *(Abstractor: William Rosenberg)*

A. A. Trapeznikov, G. G. Shchegolev, and I. I. Astakhov (Acad. of Sciences, USSR), "Electron Microscope Investigation of the Influence of the Conditions of Preparation of Lithium Grease on Its Microstructure," Izvest. Akad. Nauk SSSR, Ser. Fiz.,v. 23, 1959, 777.

Cooling conditions influenced the yield point of these greases, principally through the crystal structure of the soap. A 10% solution of lithium stearate in vaseline oil was cooled from 230 C and held at an intermediate temperature, t_1, then it was cooled to t_2=0 C. Electron microscope investigations of the resultant greases indicated that t_1 had a definite effect on the size and shape of the soap fibers, t_1=130 C yielding long thin fibers and a grease of highest structural strength. The addition of pelargonic acid during the preparation of a lithium-base grease had an appreciable effect on the character of its soap fibers. *(Abstractor: Edward H. Loeser)*

"Study of Effects of a Non-Newtonian Oil on Friction and Eccentricity Ratio of a Plain Journal Bearing", by G. B. DuBoise (Cornell University, Ithaca, New York), F. W. Ocvirk, and R. L. Wehe. NASA TN D-427, May, 1960, pp. 1-33.

Experimental and analytical investigations are made of the effect of non-Newtonian oils on the load and friction characteristics of plain journal bearings. The analysis is based upon the short-bearing equation and utilizes experimentally determined viscosity-shear rate data. For a Newtonian oil, two equivalent viscosities are computed, one giving the same friction force and the other the same load as when using a non-Newtonian oil with the same bearing operational geometry. Experimental data on friction and eccentricity are recorded for a bearing with a non-Newtonian oil, ASTM 104, which consists of a low-viscosity mineral oil-base blend thickened by adding 5% of a high-molecular-weight polymethacrylate ester. The conclusions reached are that the viscosity of a non-Newtonian oil to be used in friction calculations can be obtained from existing high-shear-rate viscometer data by using an analytically determined average shear rate which reflects the eccentricity ratio of the unit. Analysis and experiment are shown to give conflicting results on the effects of non-Newtonian oils on load capacity, and, hence, no conclusion is reached. It is concluded that this indecisiveness warrants further investigation. *(Abstractor: D. F. Hays)*

"Investigations into the Oxidation Behavior of Straight Motor Oils." Arno Klose. VDI Zeitschrift, v. 103, n. 8, 1961, p. 337. (Thesis Abstract, Bergakad. Clausthal, 1959).

Motor oils were oxidized in a closed apparatus which allows the determination of oxygen consumption and the analyses of the gaseous and liquid products. Gas chromotography is used to separate the compounds; conventional and infrared methods of analysis are employed. A simple relationship is found between the amounts of the various oxygen-containing products and changes in the infrared band at 1715 cm^{-1}. A balance sheet for the distribution of transformed oxygen among the reaction products is set up. For a motor oil, these oxygen percentages approach the following values asymptotically: water, 42; acids, 8; esters, 14; carbonyl compounds, 9; carbon dioxide, 13; carbon monoxide, 2; hydroxyl groups, 2; ether compounds, 7; and undetermined substances, 3. *(Abstractor: Edward H. Loeser)*

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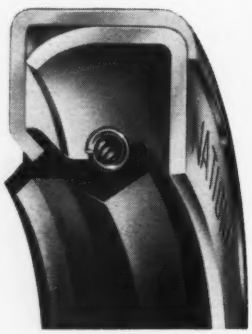

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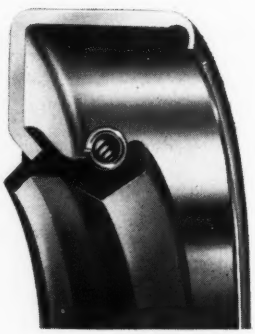

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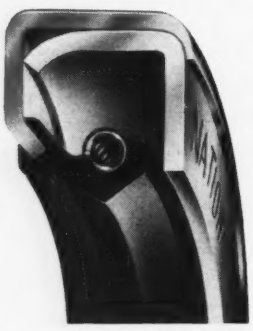

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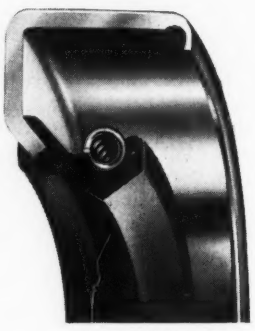

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Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

Process for Forming a Lithium-Calcium Grease Composition, Patent No. 2,959,548 (R. O'Halloran, H. G. Vesterdal and A. Beerbower, assignors to Esso Research & Engineering Co.) A method of preparing an improved lubricating grease composition which comprises a major amount of a lubricating oil and 9 to 50 wt. percent of a mixture of lithium and calcium soaps of C_{12} to C_{22} fatty acids wherein the mol ratio of said lithium soap to said calcium soap is within the range of 2:1 to 8:1, which comprises dispersing in said lubricating oil an animal fatty acid containing 12 to 22 carbon atoms per molecule and having an iodine number about 40 to 60, adding lithium and calcium bases to said dispersion, heating to a temperature within the range of 260 to 320 F. and below the melting temperature of said soaps to saponify said acids and dehydrate the mixture, cooling to a temperature below 200 F. and then homogenizing the composition at a rate of shear in the range of about 100,000 to 600,000 reciprocal seconds.

Internal Combustion Engine Lubricant, Patent No. 2,931,775 (J. L. Jezl, assignor to Sun Oil Co.) Spark ignition internal combustion engine lubricant consisting essentially of viscous mineral oil and a compound selected from the group consisting of dinitrate esters of dihydric alcohols, mono-nitro mono-nitrate hydrocarbon derivatives, and dinitro alkanes, said compound having at least three carbon atoms per molecule, in minor amount sufficient to substantially lessen the accumulation of carbonaceous deposits in the engine.

Silver Corrosion Inhibited Lubricating Composition, Patent No. 2,959,546 (J. Versteeg, assignor to Esso Research & Engineering Co.) An improved lubricating oil composition consisting essentially of a major proportion of a mineral oil, about 0.3 to 20 wt. percent of a conventional sulfur-containing antioxidant selected from the group consisting of mixtures of alkaline earth metal phenol sulfides, alkaline earth metal sulfonates and phosphosulfurized polyolefins, and an amount of a formaldehyde-producing compound equivalent to about 0.01 to 1.0 wt. percent formaldehyde based on the total weight of said lubricating oil composition; wherein said formaldehyde-producing compound releases formaldehyde as the pH of said oil drops to form an acid environment during oxidative degradation.

Heavy Pressure Lubricants, Patent No. 2,959,552 (L. Peras, assignor to Regie Nationale des Usines Renault) A lubricating composition effective to provide between surfaces in frictional contact a film which will lubricate said surfaces at all pressures, comprising a major proportion of a lubricating oil having incorporated therein 0.2 to 2% of a member of the group consisting of the methyl and ethyl esters of palmitic acid and the methyl and ethyl esters of stearic acid and 0.1 to 2% of the methyl ester of tetrachlorolauric acid in which 3 chlorine atoms are attached to the terminal carbon atom opposite the carboxyl group and the other chlorine atom is attached to the carbon atom second from said terminal carbon atom.

Lubricating Oil Composition Having High Dispersancy, Patent No. 2,959,545 (H. E. Alford, assignor to The Standard Oil Co.) A mineral lubricating oil composition exhibiting improved dispersancy consisting of from 90 to 98.5% mineral oil and from 1.5 to 10% of an additive containing from 0.5 to 3 parts by weight basic barium petroleum sulphonate and from 1 to 7 parts by weight magnesium naphthenate.

Water-Base Rust Preventive and Lubricant, Patent No. 2,959,549 (M. J. Furey, assignor to Esso Research & Engineering Co.) A rust preventive concentrate consisting essentially of mineral lubricating oil, 30 to 50 wt. percent of a mixture of sodium and barium soaps of oxidized petrolatum, wherein said soaps contain about 0.5 to 20 parts by weight of sodium per part by weight of barium, said mixed soaps having an acid number of 4 to 20 mg. KOH/gm. of soap and a saponification number of 10 to 60 mg. KOH/gm. of soap, said soap being prepared from an oxidized petrolatum having an ASTM saponification number of about 60 to 110 and an ASTM acid number of about 20 to 50, and about 10 to 25 wt. percent of an oil soluble phosphate selected from the group consisting of mono- and dialkyl phosphates and mixtures thereof containing a total of about 3 to 40 carbon atoms and wherein said alkyl radicals each contain 3 to 20 carbon atoms.

(*Continued on page* 544)

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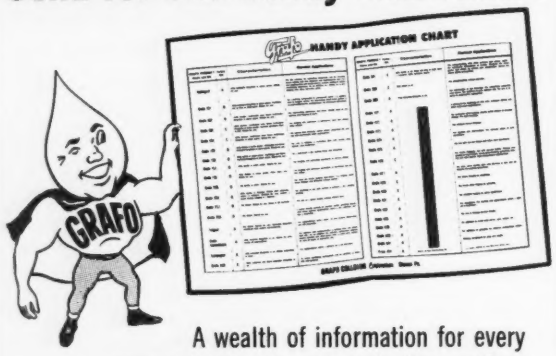

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PATENT ABSTRACTS

(*Continued from page* 543)

Lubricating Oil Composition Containing Fluorinated Dithiophosphates, Patent No. 2,959,544 (J. O. Smith, Jr. and J. V. Clarke, Jr., assignors to Esso Research & Engineering Co.) A lubricating oil composition comprising a major proportion of a lubricating oil and about .001 to 10.0 wt. percent of a fluorinated organo dithiophosphate containing about 0.01 to 1.0 wt. percent of chemically combined fluorine.

Extreme Pressure Lubricant, Patent No. 2,932,615 (T. B. Jordon and H. A. Kirsch, assignors to Texaco Inc.) An extreme pressure lubricant comprising essentially a major amount of a mineral lubricating oil containing about 3-15 percent by weight of an oil-soluble lead soap selected from the group consisting of lead naphthenate, lead oleate, lead menhadenate and lead resinate, about 2-20 percent by weight of an oil-soluble chlorinated aliphatic hydrocarbon compound having extreme pressure properties, about 8-12 percent by weight of a sulfo-chlorinated fatty oil having extreme pressure properties, and about 0.5-5 percent by weight of 2-tertiary butyl thiophene wherein the said thiophene substantially increases the extreme pressure properties of the composition.

Mold Coating Composition, Patent No. 2,932,576 (E. R. Vierk and C. A. Mazzoni, Jr. assignors to Sinclair Refining Co.) An emulsifiable oil composition consisting essentially of about 1 to 40 percent by weight of graphite electrically suspended in a neutral petroleum oil, about 1 to 15 percent by weight of a non-ionic surface active polyoxyalkylene derivative of hexitol anhydride partial long chain fatty acid ester containing about 2 to 25 mols of ethylene oxide per mol of ester, about 0.1 to 2 percent by weight of a non-ionic surface active long chain fatty acid partial ester of hexitol anhydride, about 0.1 to 5 percent by weight of a non-ionic surface active fatty ester of polyethylene glycol wherein the fatty acid portion of each of said esters contains about 12 to 18 carbon atoms per molecule, with substantially the remainder being a petroleum oil of lubricating viscosity.

(*Continued on page* 545)

PATENT ABSTRACTS

(*Continued from page* 544)

Nonvolatile Organic Compositions Stabilized by N-Alkyl p-Hydroxybenzamide, Patent No. 2,959,550 (D. W. Young and P. V. Smith, Jr., assignors to Esso Research & Engineering Co.) A lubricating grease composition consisting essentially of a mineral lubricating oil thickened to a grease consistency with the sodium soap of rapeseed oil having combined therein from 0.25% to 2% by weight of the N-C_{16} alkyl-p-hydroxy benzamide.

Lubricant Stabilized by Bis Alkylene Pyroborate, Patent No. 2,931,774 (G. E. Irish, assignor to Ethyl Corp.) A hydrocarbon lubricant containing from about 0.001 to about 1.0% of boron as a liquid bis alkylene pyroborate.

Lubricating Oils Containing Esters of Acetylenic Alcohols, Patent No. 2,959,553 (D. C. Rowlands and D. Ellis Neunherz, assignors, by mesne assignments, to Air Reduction Co., Inc.) A lubricating composition comprising essentially a major amount of a saturated aliphatic ester and a minor amount sufficient to impart extreme pressure properties to said lubricating composition of an essentially neutral ester.

Rust Inhibited Mineral Oil Compositions, Patent No. 2,935,389 (H. R. Titsworth and E. C. Martin, assignors to The American Oil Co.). A light liquid fuel fraction of mineral oil containing between about 0.0001% and 0.01% by weight of a diamine salt of an acylsarcosine, wherein the diamine corresponds with the general formula $RNHCH_2CH_2CH_2NH_2$ and the acylsarcosine corresponds with the formula $R'CON(CH_3)CH_2COOH$ in which R and R' are alkyl radicals having from 8 to 20 carbon atoms.

Lubricating Oil Additive Compatibility Improver, Patent No. 2,936,284 (A. E. Michaels, and N. V. Hakala, assignors to Esso Research & Engineering Co.) A non-turbid lubricating oil blend which consists essentially of a mineral oil base stock having combined therein about 0.05% to about 10% by weight of a viscosity index improving material selected from the class consisting of polymerized alpha, beta-unsaturated carboxylic acid esters containing from about 8 to about 18 carbon atoms in the ester portion thereof and copolymers of such esters with vinyl esters, from about 0.2% to 3.0% by weight of a detergent inhibitor selected from the class consisting of metallic salts of sulfonic acids and from 0.01% to 5.0% of a material having the formula $RO(CH_2CH_2O)_nR'$ wherein R is an alkyl group containing from 1 to 8 carbon atoms, R' is a radical selected from the group consisting of hydrogen and alkyl groups containing from 1 to 8 carbon atoms and n is an integer from 1 to 8.

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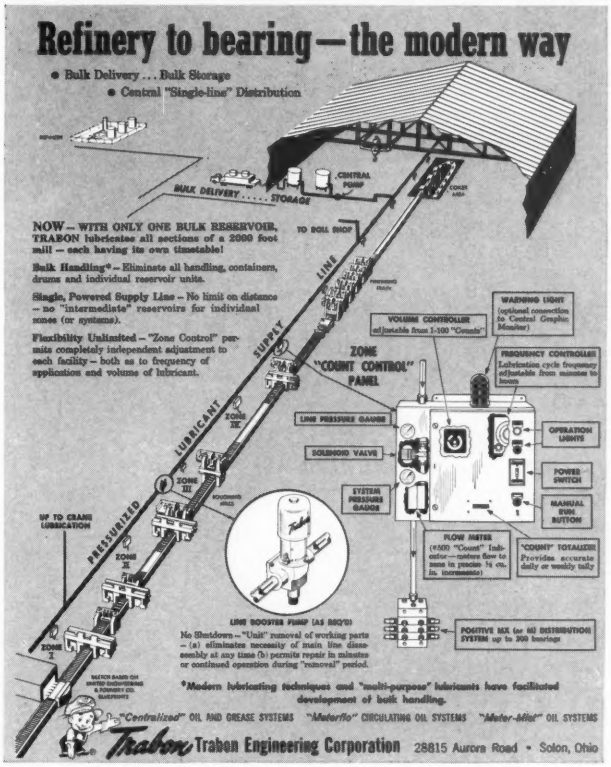
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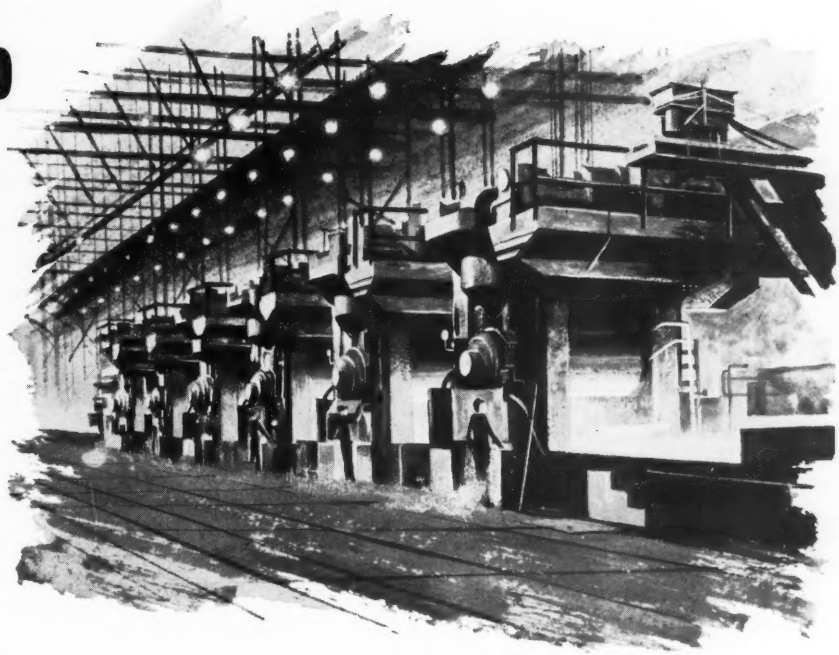

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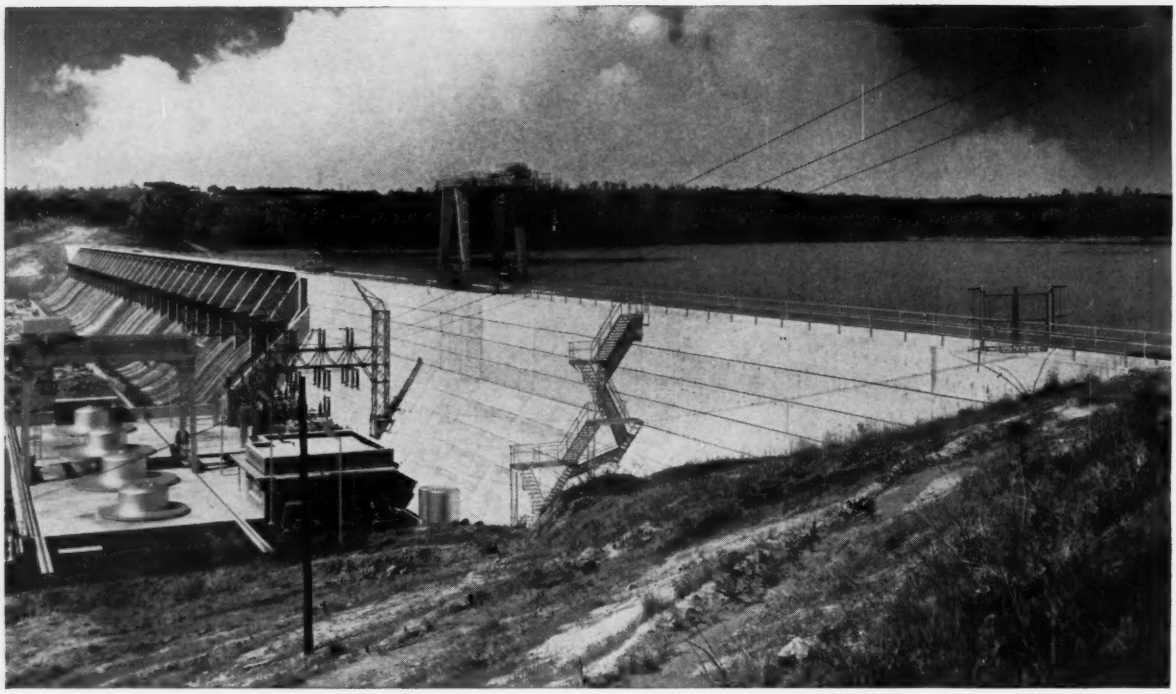

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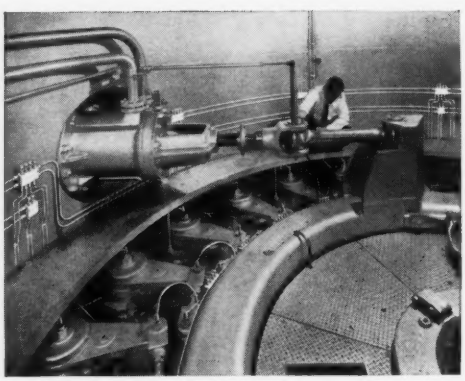

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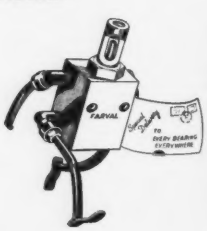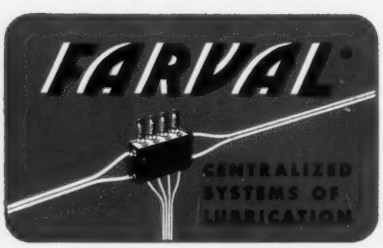
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